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HARMSWORTH SELF-EDUCATOR

1906

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A KEY TO THE HARMSWORTH SELF-EDUCATOR

At the heading of each article in the Self-Educator is the number of the group to which the article belongs, and a reference to this key indicates precisely the place of the article in the scheme of the book. This key, therefore, enables the student at any time to understand what has preceded and what is to follow any part of the work to which he may happen to turn.

Group 1.

Agriculture. Beekeeping. Gardening.

Farming. In all its Branches. Dairying. Poultry.
Beekeeping. A Practical and Commercial Course.
Gardening. How to Get the Most out of a Minimum of Land. Gardening for Pleasure and Profit. Market Gardening.

Group 2.

Art. Architecture. Glass. Earthenware. Carving.

Art (Theory and Training). Painting. Sculpture. Architecture (Theory, styles. Practical Training). History of Art.
Glass and Earthenware. Including Pottery.
Carving. Wood. Bone. Ivory. Horn. Tortoiseshell.

Group 3.

Biology. Psychology. Sociology. Philosophy. Religion.

Biology. Including Evolution. Paleontology. Heredity. Anthropology. Ethnology.
Psychology. Including Psychical Research.
Sociology. Including Political Economy.
Philosophy and Religion. History and Systems. Christianity.

Group 4.

Building. Cabinet Making. Upholstering. Fire.

Building. Excavating. Drainage. Manufacture of Bricks, Limes, and Cements. Bricklaying. Clay Wares. Reinforced Concrete. Masonry. Carpentry. Slates and Tiles. Plumbing. Joinery. Foundry and Smiths' Work. Painting. Paper Hanging and Glazing. Heating, Lighting, and Ventilation. Building Regulations. Building Abroad. In Business as a Builder.
Cabinet Making and Upholstering.
Fire. Fireproof Materials. Fire Prevention. Fire Extinction.

Group 5.

Chemistry and Applied Chemistry.

Chemistry. Inorganic and Organic. Chemistry of the Stars.
Applied Chemistry. Acids and Alkalies. Oils (Fixed Oils and Fats; Waxes; Essential Oils and Perfumes; Paints and Polishes) Candles. Soaps. Glycerine. Glues and Adhesives. Starches. Inks. Tar and Wood Distillation. Matches. Celluloid. Manure. Waste Products. Petroleum. Paper Making (including Paper Staining and Uses of Paper). Photography.

Group 6.

Civil Service. Army and Navy.

Civil Service. Municipal. National. Imperial.
Army and Navy. How to Enter Them.

Group 7.

Clerkship and the Professions.

Clerkship and Accountancy. Complete Training. Bookkeeping.
Banking. The Whole Practice of Banking.
Insurance. Life, Fire, Accident, Marine.
Auctioneering and Valuing. Practical Training.
Estate Agency. Departments and Officials of a Great Estate. Training a Land Agent.
Medicine. Training of a Doctor. Specialists. Veterinary Surgeons. Chemists and Druggists. Dentistry: The Dental Mechanic. Home and Professional Nursing.
Church. How to Enter the Ministry of all Denominations.
Scholastic. Teachers. Professorships. Governesses. Coaches. Tutors.
Secretaries, etc. Institution Officials. Political Organisations. Lecturers.
Law. Solicitors and Barristers. Personal and Commercial Law.

Group 8.

Drawing and Design.

Drawing. Freehand. Object. Geometrical. Brush. Memory. Light and Shade.
Technical Drawing. For Engineers; Coppersmiths, Tinmen, Boilermakers; Architects; Stonemasons; Carpenters and Joiners; Plumbers.
Design. Book Decoration. Textiles. Wall Papers. Metal Work.

Group 9.

Dress.

Dress. Dressmaking. Underclothing. Children's Clothing. Tailoring. Millinery. Men's Hats. Furs and Furriers. Feathers. Shirts and Collars.

Group 10.

Electricity.

Electricity. Electrical Engineering. Telegraphs and Telephones (including operation of). Cables and Insulated Wire. In Business as an Electrical Engineer.

Group 11.

Civil Engineering.

Civil Engineering. Surveying. Varieties of Construction. Machines Employed. Roads. Bridges. Tramways. Railways. Water Supply. Sewerage. Refuse. Hydraulics. Pumps. Harbours. Docks. Lighthouses. Foreign Work. In Business as a Civil Engineer.

Group 12.

Mechanical Engineering. Military Engineering. Arms & Ammunition.

Mechanical Engineering. Applied Mechanics. Workshop Practice. Tools (Hand and Miscellaneous. Machine Tools. Portable Machine Tools). Machines and Appliances (A General Guide to Construction. Clocks and Watches. Scientific Instruments).
Military Engineering. Pontoons. Bridges. Fortifications. Rafts. Trenches. Passing Rivers. Conditions in Peace and War.
Arms and Ammunition. Manufacture of Arms and Explosives.

Group 13.

Geography. Astronomy.

Geography. Physical. Political. Human. Commercial.
Astronomy. A Survey of the Solar System.

Group 14.

Geology. Mining. Metals and Minerals. Gas.

Geology. A Course in Geology.
Mining. The Practice of Mining: Coal, Gold, Diamonds, Tin, etc.
Metals. Metallurgy. Iron and Steel. Iron and Steel Manufactures. Metal Work. Cutlery.
Minerals. Mineralogy. Properties of Minerals.
Gas. Manufacture of Gas.

Group 15.

History.

History. A Short History of the World.

Group 16.

Housekeeping and Food Supply.

Servants. Qualifications and Duties of Every Kind of Servant.
Cookery. A Practical Course.
Laundry Work. Washing. The Laundry as a Business.
Foods and Beverages. Milling. Bread-making. Biscuits and Confectionery. Sugar. Condiments. Fruit. Fisheries. Food Preservation. Catering. Brewing. Wines and Ciders. Mineral Waters. Tea. Coffee. Chocolate. Cocoa.

Group 17.

Ideas. Patents. Applied Education.

Ideas. The Power of Ideas in Life. Brains in Business.
Patents and Inventions. How to Protect an Idea.
Applied Education. Application of Education in Every Walk of Life.

Group 18.

Languages.

Latin. English. French. German. Spanish. Italian. Esperanto.

Group 19.

Literature. Journalism. Printing. Publishing. Libraries.

Literature. A Survey of the World's Great Books and their Writers. Poetry. Classics. Fiction. Miscellaneous. How to Read and Write.
Journalism. A Guide to Newspaper Work, with Practical Training.
Printing. Composing by Hand and Machine. Type Cutting and Founding. Engraving and Blocks. Bookbinding and Publishing.
Libraries. Officials and Management of Libraries.

Group 20

Materials and Structures. Leather. Wood Working.

Materials. The Characteristics and Strength of Materials.
Structures. The Stability of Structures.
Leather. Leather Industry. Leather Belts. Boots and Shoes. Saddlery and Harness. Gloves. Sundry Leather Goods.
Wood Working. Design and Operation of Wood Working Machinery. Wood Turning. Miscellaneous Woodwork.

Group 21.

Mathematics.

Mathematics. Arithmetic. Algebra. Plane Trigonometry. Conic Sections.

Group 22.

Music. Singing. Amusement.

Music. Musical Theory. Tonic Solfa. Tuition in all Instruments. Orchestration. Conducting. Bell Ringing. Manufacture of Musical Instruments.
Singing. The Voice and Its Treatment.
Amusement. Drama and Stage. Business side of Amusement. Sports Officials.

Group 23.

Natural History. Applied Botany. Bacteriology. Natural Products.

Natural History. Kingdom of Nature. Its Marvels, Mechanism, and Romance. Animal Life. Flowers. Plants. Seeds, Trees, Ferns, Mosses, etc.
Applied Botany. Tobacco & Tobacco Pipes. Forestry. Rubber and Gutta Percha. Basket and Brush Making. Cane Work. Barks (Cork, Wattle).
Bacteriology. Pathological and Economic.
Natural Products. Sources. Values. Cultivation.

Group 24.

Physics. Power. Prime Movers.

Physics. A Complete Course in the Science of Matter and Motion.
Power. A General Survey of Power. Natural Sources. Liquid and Compressed Air.
Prime Movers. Engines. Steam. Gas. Heat. Turbines. Windmills.

Group 25.

Physiology. Health. Ill-health.

Physiology. Plan of the Body. Digestive, Circulatory. Respiratory, Locomotor and Nervous Systems. The Senses.
Health. The Five Laws of Health. Personal Hygiene. Environment. State Medicine and the Public Health.
Ill-health. General Ill-health. Its Special Forms. Common Ailments and Domestic Remedies.

Group 26.

Shopkeeping. Business Management. Publicity.

Shopkeeping. A Practical Guide to the Keeping of all Kinds of Shops
Business Management. The Application of System in Business.
Publicity. Advertising from all Points of View As a Business.

Group 27.

Shorthand and Typewriting.

Shorthand. Taught by Pitmans. Typewriting. Working and Management of all Machines.

Group 28.

Textiles and Dyeing.

Textiles. The Textile Trades from Beginning to End.
Dyeing. Dyes and Their Application.

Group 29.

Travel and Transit.

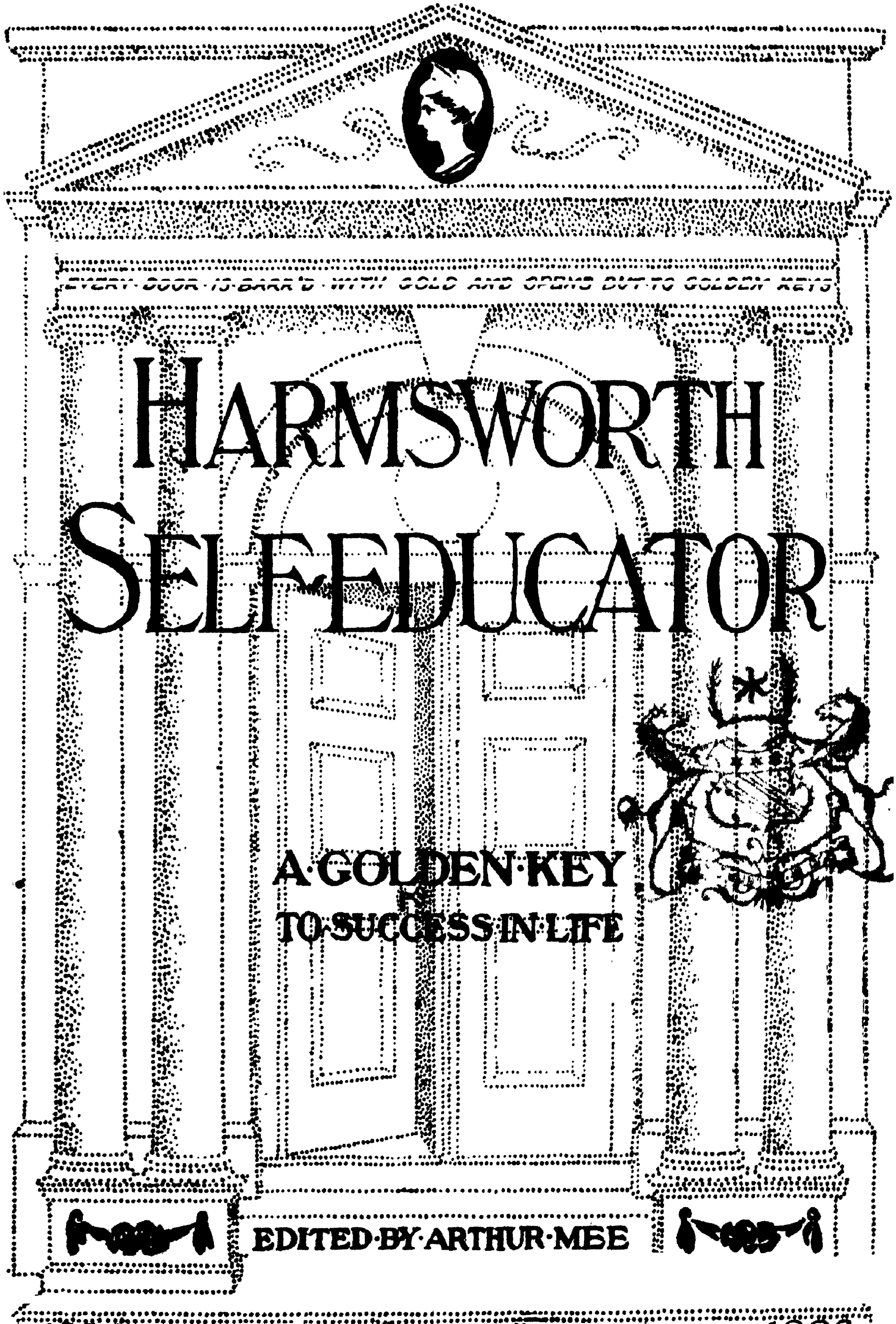
Travel. How to See the World. The Business Side of Travel.
Transit. A General Survey of Means of Communication.
Vehicles. The Construction of Air, Land and Sea Vehicles.
Railways. The Management and Control of Railways.
Ships. Shipbuilding. Shipping. Management of Ships.

A Picture by W. Lee Hankey, illustrating the Modern Style

A Picture by J. M. W. Turner, R.A., illustrating the Old Style

WATER-COLOUR PAINTING: THE NEW AND THE OLD

[See Art]



EVERY·DOOR·IS·BARR'D·WITH·GOLD·AND·OPENS·BUT·TO·GOLDEN·KEYS

HARMSWORTH SELF EDUCATOR

A·GOLDEN·KEY TO·SUCCESS·IN·LIFE

EDITED·BY·ARTHUR·MEE

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THE LIFE HISTORY OF WHEAT

Cereals are Cultivated Grasses. Structures of the Wheat Plant. The Flowers. The Grain. Germination. Varieties

Continued from page 912

By Professor J. R. AINSWORTH DAVIS

THE beginnings of agriculture in Western Europe have been traced back to the remote pre-historic times when weapons and implements were made of polished stone, and the valuable properties of metals were unknown. We can only conjecture as to the manner in which the cultivation of wild plants began; but it has been suggested that the practice arose in the superstitious custom of burying berries and grains with the bodies of deceased friends, to serve as food for their ghosts. The plants springing up from these offerings would no doubt be more vigorous than their wild congeners, and the discovery that the turning up of the soil had to do with such a result might ultimately be made. In some such way as this the importance of tillage no doubt gradually came to be independently perceived by wild tribes living in different localities.

Our Debt to the Grasses. By taking advantage of the stores of nutritive matter that grasses lay up for the benefit of their offspring, to say nothing of the value of the plants themselves as food for domesticated animals, the evolution of civilisation has been immensely furthered. Wheat, barley, oats, and all other cereals are simply cultivated grasses, the value of which has been enormously enhanced by the increase in size and number of their grains as the result of thousands of years of tillage. Till now it is estimated that wheat, the type we are considering, is capable of yielding some 2,000 pounds of food per acre. How best to increase this yield and to extend the wheat-growing area are among the most pressing economic problems of the present time, and their solution will obviously be more and more urgent as time goes on.

Structure of the Wheat-plant [158]. Without repeating what has elsewhere been said about the characters of grasses in general, it may be remarked here that the hollow stems are eminently adapted for supporting the heavy ears, and that the main root of the seedling remains undeveloped, the root system consisting of a multitude of branching fibres which ramify through the soil. As, from the nature of the case, the plant becomes more and more top-heavy as its value increases, it is clear that the selection of varieties with a vigorous and extensive root system is a matter of great importance. Besides which, the soil must be sufficiently firm to afford a good hold. Failing these conditions, the two great enemies of the crop—wind and rain—especially when acting in conjunction, may play sad havoc. And these conditions have much to do with determining the extent of the area available in the future as wheat-land.

Flowers of the Wheat. An ear of wheat (*Triticum vulgare*) consists of numerous crowded spikelets, each of which contains several flowers invested in scaly glumes or bracts [159]. In "bearded wheat" some of these are drawn out into long threads or awns. On examining a single flower [160], we find that it possesses a pair of small scales, the *lodicules*, which possibly represent the covering leaves or perianth—*i.e.*, the conspicuous part of an ordinary sort of flower. There are three stamens with long slender filaments, to which the anthers are so attached that they swing about very easily. They produce an abundance of dust-like pollen. The pistil consists of a single carpel, crowned by two feathery styles, of which the branches serve as stigmas or pollen-catchers. The swollen base of the pistil—*i.e.*, the ovary—is destined to become the wheat-grain, and contains a single ovule or incipient seed.

Pollination and Fertilisation. The flowers do not open thoroughly unless the temperature is a little over 60° F., and here the lodicules play an important part, for they swell up and force the investing scales apart. This usually takes place in the morning. The anthers of the projecting stamens are easily moved by the wind, which carries some of their pollen to other flowers, thus effecting crossing, the feathery styles catching any grains that may chance to be blown against them. A certain part of the pollen remains in the same flower, and may effect self-pollination, which is effective. In unfavourable weather the flowers do not open at all, and crossing cannot then take place. Flowering begins and ends the same day. The grains which result from crossing are larger and healthier than those produced by self-fertilisation.

Structure of the Wheat-grain. A grain of wheat is of elongated shape, with a groove running along one side [161]. It is a fruit, and not a seed, and is covered by a rather thick membrane representing the wall of the ovary and the seed-coat, which are closely adherent. The great mass of the grain is a food store for the embryo, which may be seen at the base of the ungrooved side [162], and consists of a primary shoot (*plumule*) and a primary root (*radicle*), around which is folded the single seed-leaf or *cotyledon*. The central part of this is termed the *scutellum*, and is closely applied to the food store or endosperm [163].

Examination of a microscopic section of part of the grain [164] shows externally the membranous investment alluded to above. This is the "bran," which is retained in brown bread, and removed in white. Under this is a layer of "gluten-cells," containing granules of albuminous nature. Since this is largely milled away in grains destined to make white bread, this bread is less nutritious than brown bread. Within this again, larger cells crowded with starch make up the greater part of the endosperm.

Germination of Wheat. Given moisture, air, and a fairly high temperature, the wheat-grain begins to germinate [165]. The plumule elongates and pushes its way above ground, to give rise to the stem and leaves, while the radicle breaks out and grows down into the ground. Its development, however, is soon arrested, and most of the wheat-roots are derived from the lower part of the stem.

Until the seedling is able to get its own living, it feeds upon the endosperm. The nutritive matters in this have to be converted into a soluble form before they can be absorbed by the embryo. This is the work of the scutellum, which produces substances known as *ferments*, that digest the endosperm in much the same way that food is digested in the animal body. That is to say, the practically insoluble starch and gluten are converted into soluble materials (sugar in the case of starch), which are absorbed by the scutellum, and diffuse into the growing shoots and roots. By the time the endosperm is used up, the seedling is able to draw upon the air and soil for its food supply.

Crossing Varieties of Wheat. As in the case of other domesticated plants, a number of different varieties or races of wheat have come into existence in the course of time [166–7]. It has been found possible to cross these artificially by transferring the pollen of one variety to the stigmas of another, with remarkable results, for the ears of some of the mongrel plants so produced are of extraordinary size [168–71]. Experiments of this kind, conducted on wheat and many other plants, have yielded valuable data on which to found theories of heredity, careful observations being made and tabulated of the characters inherited from the parents. Such experiments are not particularly difficult to conduct in many cases, and are of great importance both scientifically and economically. [For details see BIOLOGY.] The essence of the matter in the latter aspect is that it appears to be possible to produce mongrel types which combine the desirable character of the parent forms, or it may be to eliminate those which are undesirable. This is but one of many examples which illustrate the value of science in relation to industry, and lead to the conclusion that unless the Government of this country is prepared to endow scientific research to a much larger extent than has so far been the case, we shall in the end be left far behind—commercially—by Germany, the United States, and other countries which are fully alive to the vast importance of the matter.

Sources of our Wheat Supply. In round numbers we may estimate the annual consumption of wheat in the United Kingdom at 30,000,000 quarters, of which only 6,000,000 quarters are home-grown. Unfortunately, owing to external competition, the amount of British wheat produced has been rapidly declining since 1870, and is continuing to do so, which has not only a disastrous effect in furthering the depopulation of our rural districts, but makes us increasingly dependent on foreign countries, especially the United States and Russia, for the most important item in our food-supply. Unfortunately, too, average British wheat compares unfavourably with foreign, for it contains a larger amount of moisture, and a smaller percentage of nitrogenous matter (gluten).

Less than one-third (about 27 per cent.) of imported wheat and flour is derived from British possessions, but, luckily, the proportion is on the increase, and we may hope to see the time when the Empire is able to feed itself. Large quantities are grown in the more temperate parts of India, and in Australia, but it is mainly to Canada that we must look as an increasing source of supply.

Canadian Wheat. The vast plain of Central Canada presents very large areas which are eminently suitable for wheat-growing. The soil is a stiff clay, which not only affords firm support to the roots, but is also very retentive of moisture. And it is covered by an ancient and very rich deposit of loam, which serves as a sort of natural manure. So much is this the case that, in some instances, the crop has been continuously grown for from 20 to 30 years without the application of any artificial fertilisers. Of course, the time will ultimately come when these will have to be applied in all cases, but that time is not yet.

The long summer days of Canada are extremely favourable to the ripening of grain, and their influence is enhanced by the south-west anti-trade winds, which, after blowing over the Rockies, are warm and dry. Despite the dryness of these winds, an abundant supply of moisture is available, for the great cold of winter furrows the ground with deep cracks, in which snow collects, being stored up, as it were, in underground reservoirs. When this snow melts, it yields the requisite water.

It may be added that the facilities for water-carriage to the Atlantic sea-board are unrivalled, nor are there great difficulties in the way of railway construction. The Canadian farmer has, it is true, to contend with summer frosts and floods, but the former are successfully combated by lighting fires of damp straw ("smudge-fires") to the north side of the crop on nights when frost is threatened. And it seems probable that an increase in the area of tillage will gradually more or less obviate the danger of floods, by averaging the distribution of rainfall, and tree-planting may also do something in the same direction.

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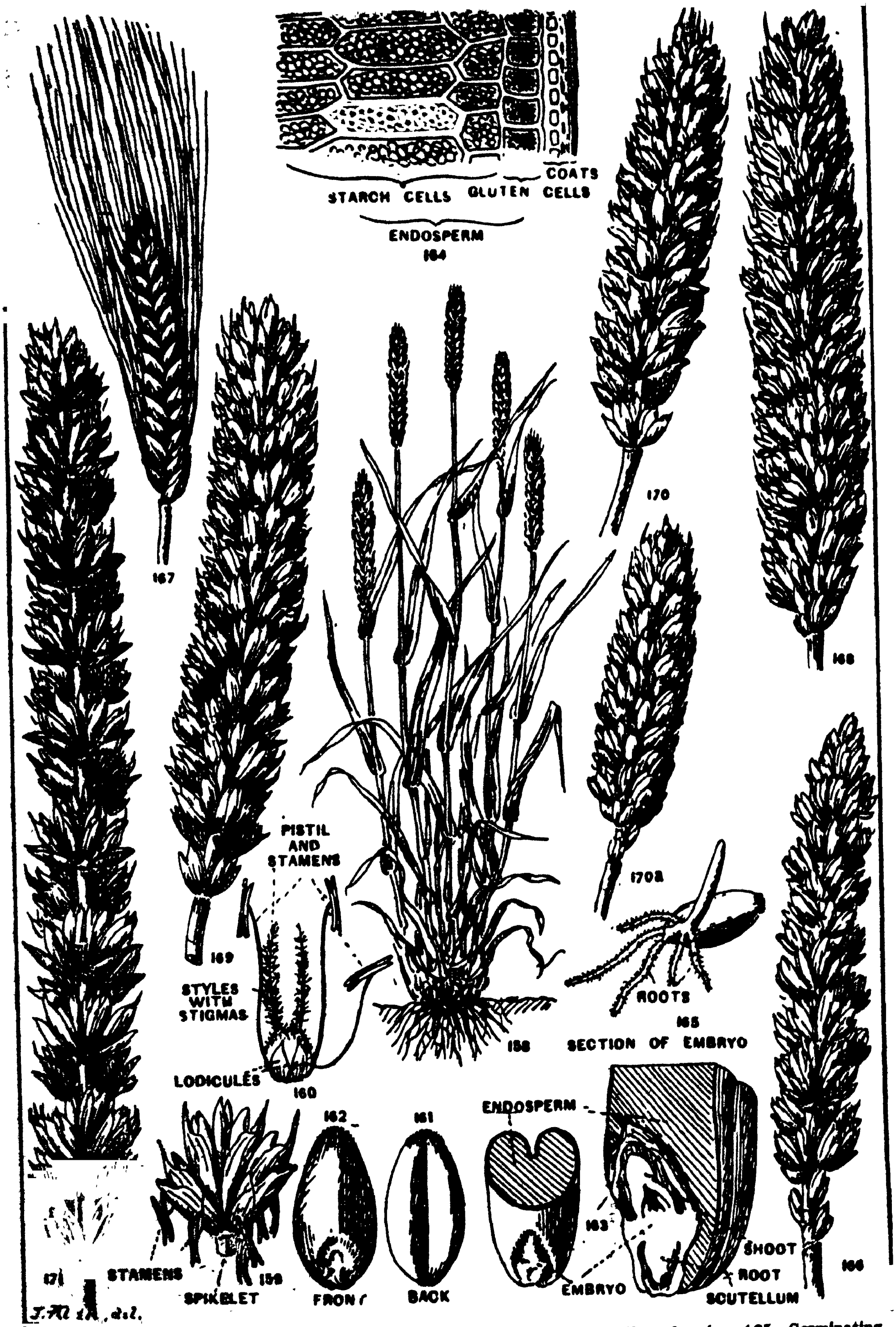

158. Wheat plant. 159-60. Details. 161-3. Wheat grains. 164. Section of grain. 165. Germinating grain of wheat plant. 166. Talavera. 167. Red Emmer. 168. Hundredfold Pedigree. 169. Flourball. 170. Red Stand-up Pedigree. 170a. White Stand-up Pedigree. 171. Hallett's Pedigree Wheat, 1861

Group 4
BUILDING
7

Continued from page 784

SHORING AND UNDERPINNING

The Use and Construction of Raking and Flying Shores, and of Needles for Underpinning. Methods of Dealing with Dangerous Structures

By Professor R. ELSEY SMITH

SHORING consists in providing temporary support to a building by means of a system of wooden struts resting on solid ground or against another building. It is employed in cases where buildings show signs of failure due to sinking of the foundations, vibration of machinery, or other causes, and demands much judgment and very great care in execution.

It is also used where a building which is attached to one or more other buildings is to be taken down for rebuilding. In a row of houses —*e.g.*, each one gives lateral support to its neighbours, and were a single house in a row removed there would be great liability of damage to the houses which are on each side, and are entitled to the support previously afforded them, and shoring is erected to give this support temporarily until the reconstruction is complete.

A Typical Shoring Scheme. The key plan [60] represents three houses in a line, of which the central one is in course of reconstruction, while that on the left is to have the ground-floor taken out to insert a girder and shop front. It illustrates the position in which the various shores described hereafter are used.

Shores, as applied to walls constructed mainly of brick, are of two principal types. *Raking shores* [58] are those one end of which rests on the ground, while the other is inclined against the face of the wall to be supported. *Flying shores* [56] are those placed horizontally between two buildings. In the case of raking shores, if the building to be supported be a low one, a single strut may suffice, but in most cases, where the buildings consist of several storeys, a *system* of shores must be used—two or more struts in the same plane, abutting against and steadying the wall at different levels. Wherever possible, the head of each strut should be arranged at or just below the level of a floor, where the wall is stiffened internally and is best able to resist external pressure. The object of shoring in the case of dangerous walls is not, as a rule, to force back into position a wall that is out of the perpendicular, for any such attempt might result in disaster, but to prevent any further movement of the wall till it can be dealt with in a permanent manner.

Constructing a Shore. A shore is constructed as follows [61]. A wall-piece is placed vertically against the wall to be supported. This is usually of considerable length, 9 by 3 in. thick, and is held to the wall by holdfasts carefully driven. If the wall be bulged or uneven, packing must be placed between it and the wall-piece to secure an even bearing against the wall. Where the head of the shore abuts [55], a 3 or 4 in. square hole is perforated through the piece, and a bat or half brick is removed from the face of the wall. A short timber, or *needle* is placed through the hole entering the wall where the bat is removed, and above it a block of wood, termed a *cleat*, is spiked to the wall-piece, and thus a firm abutment for the head of the shore is formed.

For the foot of the shore [57] a stout timber is provided, termed the *sole-piece*. If the ground be good, it may be carefully bedded upon it; but if the ground be soft, a small platform of stout planks, or in some cases even of concrete, will be necessary. Should a vault exist where the foot of the shore comes, it must be supported with dead shores—hereafter described—or, better, the shore must be taken through the vault to the solid ground. The sole-piece is not placed horizontally, nor is it perpendicular to the shore, but at an intermediate angle.

The sole-piece and wall-piece being in position, the shore itself is cut to the required length. The head is notched to fit round the needle and prevent any possibility of lateral movement, and the underside is cut so as to rest against the wall-piece. The foot is also cut to a bevel to correspond with the inclination of the sole-piece, and at the back of the shore a small notch is cut to allow of a crowbar being inserted. The shore is placed in position, and if the wall be dangerous great care must be exercised to prevent any damage to the wall during this process. The foot rests on the sole-piece with the head against the needle, at first loosely, but with the help of a crowbar the foot is gradually moved forward along the sole-piece until the notch is tight up against the needle. If it be moved beyond this, there will be a tendency for the head to lift the needle and damage the wall. When in position the foot is secured by *dog-irons* [54]. These are bars of iron with ends bent at right angles and pointed. They may be driven into the foot and the sole-piece, or a cleat may be fixed behind the foot. In the case of dangerous walls this method of fixing is better than tightening by wedges as less likely to disturb the brickwork. The shore is stiffened to resist transverse strain or buckling, by braces formed of boards placed on either side and securely nailed to it at one end, and to the lower part of the wall-piece at the other.

A System of Shores. Where a system of two, three, or four struts—one above another—is employed, the method is similar [58]. The length of the wall-piece is increased to correspond with the height of the building, and the head of each shore is prepared as described, and has a needle provided for its abutment. The feet are brought close together on the sole-piece, and each shore in the system is of a different length and at a different angle. In such a system, when the shores are in position, a strip of hoop-iron is wound tightly round near the foot and nailed to the various timbers, binding them together, and the braces extend from the wall-piece to the outermost shore, and are nailed to the intermediate ones. This occurs at two or three points in the height in each case, starting from the wall-piece just below the head of a shore. Great rigidity is thus secured.

Shoring High Buildings. With lofty buildings it may prove difficult to obtain timbers of sufficient length for the outermost shore. In such a case, when the last raking shore is fixed, another piece of timber is placed against the back of it, resting on the sole-piece. The top is cut to a bevel, and the foot of the shore rests on the top of this post, the head being formed as usual. This is termed a *riding shore*, and cannot be levered into position, but must be wedged with folding wedges of oak inserted between the upper and lower parts of the shore, driven in from each side, care being taken not to lift the rider more than is required just to tighten it.

The number of such systems required to steady any given wall will vary with the circumstances, and in particular with the condition of the wall itself, depending on whether the brickwork is sound and well constructed, or tending to disintegrate. They should not be more than 12 or 15 ft. apart, and may be much closer. If the wall is pierced with window openings, the shore systems must correspond with the piers between them.

Shoring is sometimes required in connection with the timbering of excavations. The horizontal struts used in wide excavations form practically flying shores, which will be described later; but an excavation may be too wide to allow of strutting each side from the opposite one. In such cases raking struts, or shores, must be provided to sustain the walling pieces, and they can often be used with greater efficiency than in the case of a building, as it is frequently possible to place them at a comparatively low angle with the horizon.

Work of the Shore. The work required of a shore, or shore system, is to resist the tendency of a wall to fall outwards, by pressure behind it, which is greatest when just sufficient to overturn the wall. This pressure, or force, acts perpendicularly to the wall through the head of the shore. It would be best resisted by a strut also perpendicular to the wall; but, except in the case of flying shores, this cannot be provided. With a raking shore part of the force exerted is expended in holding up the wall vertically, and part only in resisting overturning, the amount depending on the inclination of the shore to the horizon, the lateral resistance being greatest when the inclination is low. An angle of 40° is useful, but so low an angle is rarely practicable, and angles from 60° to 75° with the horizon are very usual.

Formula of Forces in a Shore. The following formulæ may be used for calculating the forces acting upon a shore [61]. *

$$Q = \frac{W \times t}{2\,H},\ P = Q \tan\theta - \frac{w}{2},\ F = P \sin\theta + Q \cos\theta$$

Q = the overturning force, P = the force due to weight of wall above shore, F = the resistance to compression in the shore, W = the weight of wall, all in cwts., t = the thickness of wall at ground in feet, H = the height of the head of the shore from the ground in feet, θ = the angle of inclination between the shore and the horizon, and w = the weight of the shore itself in cwts. The dimensions of the shore, when F has been calculated, may be found by Rankine's or other formulæ for timber struts.

In a system of shores it is sufficient to calculate the outermost shore, and to use timber of the same size for all, and a builder will usually employ timber in stock for this purpose even if of somewhat larger scantlings than required.

The number and sizes of shores usually required in each system are: *

Height of wall.	Number of shores in system.	Scantlings of each shore in system
15 ft. to 20 ft.	2	5 in × 5 in.
20 ,, ,, 30 ,,	2	6 ,, × 6 ,,
30 ,, ,, 35 ,,	3	7 ,, × 7 ,,
35 ,, ,, 40 ,,	3	8 ,, × 8 ,,
40 ,, ,, 50 ,,	4	9 ,, × 9 ,,
50 upwards	4	12 ,, × 9 ,,

The material used for shoring is usually fir, Dantzic being particularly suitable on account of its straight grain. For very long shores, however, it may be difficult to obtain this timber of sufficient length, and pine is sometimes used. But this is more expensive, and is therefore avoided, when possible, for what is merely temporary work. The wedges should be of oak, as offering greater resistance to compression than fir, and the sole-piece may usefully be of the same material. Care must be taken to see that all bearing surfaces are truly cut, so that when in position they will be in contact all over.

Flying Shores. *Flying*, or *horizontal* shores [56] are employed wherever a suitable abutment can be secured above the ground level. Their most common use is when a house between two others is temporarily taken down and the buildings on each side require mutual support, but they may be employed across a court or street in the case of a dangerous building, with the consent of the owner of the opposite building, who is, however, at liberty to withhold it.

The great advantage of a flying shore is that the principal timber is placed perpendicularly to the face of the wall, and therefore directly counteracts the overturning force.

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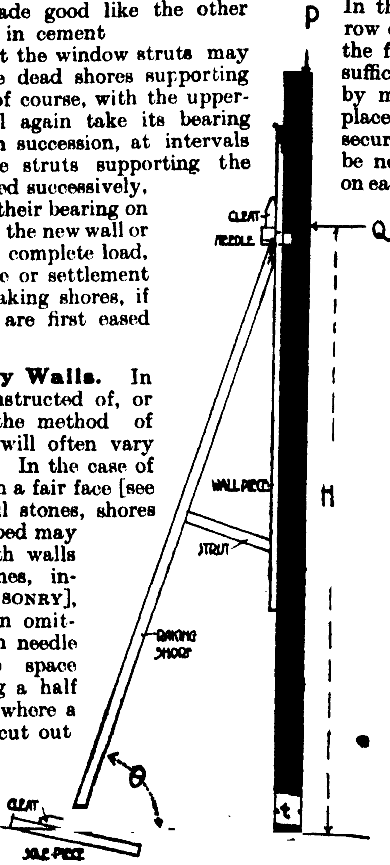
* C. Haden Stock. "Shoring and Underpinning."

of the wall, and upon this brickwork is built in cement under the lengths of wall between the needles, and the new brickwork is pinned up tight under the old. If possible, the levels should be adjusted so as to allow of an exact number of brick courses being used, but if this is not possible the necessary thickness may be made up with hard slates or tiles set in cement.

Striking Underpinning and Shoring. Seven days are usually allowed for setting, then the needles are gradually eased by loosening the wedges or lowering the jacks, so that the wall takes its bearing on the girder. They are afterwards removed, and the holes occupied by them made good like the other parts with brickwork in cement

When this also is set the window struts may be taken out, and the dead shores supporting the floors, beginning, of course, with the uppermost floor, which will again take its bearing on the wall. Then in succession, at intervals of a day or two, the struts supporting the lower floors are removed successively, and they in turn take their bearing on the wall; lastly, when the new wall or girder has received its complete load, and no signs of failure or settlement are observable, the raking shores, if they have been used, are first eased and then struck.

Shoring Masonry Walls. In the case of walls constructed of, or faced with stone, the method of applying the struts will often vary from that described. In the case of rubble walls built with a fair face [see MASONRY] and of small stones, shores similar to those described may be employed; but with walls built of larger stones, including ashlar [see MASONRY], the wall-piece is often omitted. The small wooden needle which fits into the space occupied by removing a half brick is not suitable where a large stone has to be cut out In this case a header of hard stone is inserted and allowed to project beyond the face of the wall, and beneath it a piece of oak is placed, to form a seating to receive the head of the shore.



61. DIAGRAM OF FORCES ACTING ON A SINGLE SHORE

Occasionally when great strength is required at some point in a wall, two systems of shores may usefully be employed close together; in such a case the systems are advantageously arranged not parallel to each other in vertical planes, but converging so that where the struts impinge upon the wall they are close together, while the feet and the sole pieces they rest in are wider apart, and if two such systems are well braced laterally, great strength and stiffness is secured.

Shoring Ruinous and Dangerous Structures. The method of dealing with ruinous and dangerous buildings will vary greatly with the nature of the structure and the extent and nature of the failure or damage. This is liable to so much variation that nothing but very general particulars can be given. The first essential is to steady and uphold the building to prevent its collapse. For this purpose raking or flying shores are usually employed. When the building has been temporarily secured, needling may take place to enable defective foundations or lengths of walling to be removed and reconstructed.

In the case of buildings supported on a row of detached piers or arches, in case of the failure and cracking of a pier, it may suffice to uphold the capital of the column by means of a strong frame of timber placed round it and strutted up from a secure base; but in other cases it may be necessary to shore up the two openings on each side of it upon a strongly-framed centre, such as is used for constructing an arch, and which will be described later.

Old Buildings. In all cases in which old buildings require to be dealt with, it is very necessary that they should be carefully examined, and the condition of the materials and structure ascertained, not merely on the surface of the wall, but in its heart. In many mediæval buildings walls are found constructed with a comparatively thin external skin of good masonry, while the heart of the wall is formed of rubble or concrete; if the lime used in forming the concrete was not originally of good quality this may have disintegrated. In such cases it is impossible to employ needling unless the core can be first rendered solid by the introduction of grouting [see BRICKLAYER]. It will usually be necessary to compute carefully the weight of the old building or the part of it which is to be dealt with; this is particularly necessary where any building of considerable height such as a tower has to be upheld, as the loads to be supported may be considerable. In such a position, too, there is often very considerable difficulty in finding adequate room for the necessary supports without seriously encroaching on the working space and rendering the work of reconstructing those parts of the structure that have to be reinstated extremely awkward and difficult. With structures of great height and weight the work may sometimes be quite as economically done by taking down and reinstating the work as by shoring and underpinning it; other considerations than cost may however render the latter course the better one.

Continued

TONIC SOL-FA

TONIC SOL-FA continued from page 807

Division of Pulses. Rests. How "Holds" are Indicated. The Theory of Transition. Major and Minor Modes

By J. CUTHBERT HADDEN

THUS are the individual full pulses of the various measures marked out. We have next to consider how the pulses themselves are divided and extended. Here, again, the same simple means are adopted ; for all time divisions and extensions whatsoever are indicated by just three symbols—the dot, the comma, and the dash. A pulse is divided into halves by placing a dot in the middle of it ; into quarters by a comma in the middle of each half (for you must show the half division first) ; and into thirds (" triplets " is the Staff term) by two inverted commas. When a note is to be continued from one pulse into the next, the continuation is indicated by a horizontal line (or dash). A little illustration may be made to include all these time forms :

|d :m .s |d :r .m |f :s,f.m,f |s :l‘s‘f |

|m :— |s :— |d :— |— :— ‖

The first measure introduces halves, the second measure quarters and thirds, and the last two measures show continued notes. Of course the continuation mark does not necessarily go always through a full pulse. Thus we may write :

|d :– .d |m :– .r |s :– .f,m |r :d ‖

where the continuation is for only a half-pulse. Similarly, a continuation may be carried into a third of a pulse, as here :

|d :— |–‘s‘f :m‘r‘m |s :— |–‘f‘r :d ‖

There are, again, other forms of quarter division of the pulse besides the four notes of equal length. A pulse may, for example, contain a half-pulse note and two quarter notes, as here, where at *a* the half-pulse comes first, while at *b* the two quarters come first :

(*a*) (*b*)
|d .s :m .r,m |s .f :m,r.d ‖

Another very common time division is shown in the following illustration, where we have a succession of pulses, each containing a three-quarter and a one-quarter note :

|d .,r :m .,f |s .,f:m .,r |m .,s:f .,r |d :— ‖

This time-form is frequently met with in marches and other music of a bold and swinging character.

In advanced classical music many curious and minute subdivisions will be met with, the time notation of which—from what he has already learnt—the student will, as a rule, readily understand from the context. Special note should, however, be made of the way in which sixths, eighths, and ninths are written. The following illustration is taken from the authorised " Tonic Sol-fa Time Chart," which the earnest student of the notation should always keep beside him for reference :

Eighths	*Sixths* (*Three Accents*)
l l ,l l .l l ,l l	:l l ‘l l ‘l l
Ninths	*Sixths* (*Two Accents*)
$\overset{3}{\text{l}}$ l ‘l $\overset{3}{\text{l}}$ l ‘l $\overset{3}{\text{l}}$ l	:l $\overset{3}{\text{l}}$ l .l $\overset{3}{\text{l}}$ l

Rests in Tonic Sol-fa are not indicated by characters, as in the Staff. The pulse, or part of a pulse, is simply left empty ; there is nothing in it to sing. Thus, at *a* there is a full pulse rest at the end of the measure ; at *b* a similar rest at the beginning of the measure :

(*a*) (*b*)
|d .t_1 :d |r : | :d .t_1 |d .r :m ‖

Rests may be of any length, long or short. A half-pulse rest is indicated by a blank space on one or other side of the dividing dot. Thus, in the first half it will appear as

: .l |l .l : .l |l

in the second half as

|l .l :l . |l .l :l . ‖

Quarter rests are just as readily indicated to the eye. For example, we see at once that here

: ,l .l ,l | ,l .l ,l

the first quarter is silent, while here

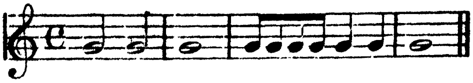
:l ,l .l , |l ,l .l ,

the silence is in the last quarter. Silent thirds may appear at first to be less clear. The following are the forms more generally met with :

First Third Silent .. .. .. : ‘l ‘l
Second Third Silent .. .. :l ‘ ‘l
Third Third Silent .. .. .. :l ‘l ‘
Second and Third Thirds Silent :l ‘ ‘

The whole matter of time-notation may seem, on first acquaintance, a little puzzling to the student. It is certainly much more original and novel than the notation of tune. But it is founded on a skilfully conceived and well thought out system, and the singer will soon discover that there is less difficulty in theoretically understanding the various subdivisions of the pulse than in giving practical effect to them by his voice.

One very important point has to be noted about the writing of Sol-fa time-notation. It was a point upon which Mr. Curwen laid great stress, and it is this, that each pulse in the same line of music must occupy exactly the same lateral space. Mr. Curwen would illustrate his meaning by showing how in the Staff notation this rule is disregarded, as, for example:



Here the measures and pulses fill very different spaces, according to the number of notes they contain. In Tonic Sol-fa they must be made equal, as thus:

|s :— |s :— |s :— |— :— |

|s .s :s .s |s :s |s :— |— :— ||

The pulses, to quote Mr. Curwen once more, are "measured out, like the inches on a yard measure, and the eye rapidly values the length. An experienced Sol-faist keeps time by judging the distance between the notes, only stopping occasionally to look at the accent marks; and when through bad printing the pulses are unequal, he is completely put out." In writing Tonic Sol-fa, then, see that the accent marks are equidistant, and that, moreover, the medium accent and the weak accent are of a size with the notes. The strong accent should be at least double the length of the medium. Here is a bad but common specimen of Sol-fa manuscript:

|d :m / r :d .m| s : l |t. l : s |

Should be written:

|d :m |r :d .m |s :l |t .l :s |

Practically, the Tonic Sol-fa notation is a notation which gives visual expression to tune and time. It sets down the notes of the scale in its own peculiar way, and it indicates the lengths of the notes, also in its peculiar way. Beyond that, it may be said to correspond with the Staff. Its signs for *staccato* and *legato*, for example, are the same. Thus, when a note has to be struck in a short, disconnected manner, it is marked above with a dot. If the *staccato* is to be crisp—very pronounced—a dash is used: in both cases just as in the Staff. "Holds," again, are common to both notations. The sign 𝄐 is familiar. It means that the note is to be "held" or prolonged at the will of the performer. Thus, a three-pulse *Doh* with a hold over it might be made to occupy the time of five pulses. The hold is of the nature of a rhythmical licence. Repetitions, again, are indicated, as in the Staff, by the use of "Da Capo," or "D.C.," meaning "return to the beginning," etc. In everything that relates to the expression of the music, to its manner of rendering as regards force and intensity, soft and loud, fast and slow, etc., the two notations make use of common terms. It would thus be superfluous to repeat the information given under this head in the Staff notation papers, which the Tonic Sol-fa student may consult with profit to himself. He will find in the glossary in part 1, page 42, a list of all the musical terms generally used for the direction of singer or player.

There is just one variation to be noted in this connection. In the Sol-fa notation the sign for the slur takes rather a different form from that used in the Staff. In the Staff, when two or more notes are to be sung to one syllable, a curved line is drawn over them. In Sol-fa, the plan is to draw a *straight* line *under*. So long as the line continues, only one word, or one syllable, as the case may be, is to be sung. Thus:

.s₁ |d :d |d,r.m,f :s .d |r :r .m,f |m

When Bri - tain first at heav'n's com - mand.

In the Tonic Sol-fa notation there are no signs of phrasing, as in the Staff.

When a change of key occurs there is never any doubt about it in the Sol-fa notation. Let it be premised that Sol-faists distinguish very sharply between transition and modulation. "Modulation," says the Staff theorist, "is the passing from one key to another." The term transition, he admits, "is also used, though principally to designate very brief modulations to keys not dwelt in." The Sol-faist, on the contrary, makes transition refer to all changes of key whatsoever, transient or of lengthened duration; while the term modulation he confines strictly to a change of *mode*—from major to minor, or *vice versa*. We will take transition first, the passing for the time being into a new key, where the old governing *Doh* gives up its place to a new *Doh* founded on a certain note of the old key. Before explaining how the notation expresses this, we had better clearly understand the nature of transition itself.

In a very short composition—a four-line hymn tune, for example—the composer may feel quite satisfied to remain in the one key throughout, though even in the shortest compositions transitions are often found. In a longer work the ear of the listener gladly welcomes, if it does not actually demand, a shifting of the *Doh* on to some other sound than that with which the piece began. In every instrument, as Mr. Curwen puts it, there is only a certain limited range of sounds at the composer's command, and he seeks to approach these from every point of view, to clothe them in every colour, and to make his changes as pleasantly striking as possible. Mr. Curwen insists that the pupil must be made, first of all, to *feel the need* of transition. This is easily possible by directing his attention to certain melodic factors of transition in which *Te* and *Fah*, the distinguishing notes of the scale, play the chief part. Look at this little bit of tune:

:d |m :– .m |r :d |f :f |m :r |

|m :s |s :f |s :— |— ||

Does not the ear instinctively feel that something is wrong about the next last note? The ear wants the *Fah* to be a "leading note" to *Soh*—feels, in short, that the *Fah* ought to be raised a semitone, so that these two notes shall sound like a new *Te Doh*. If we take it thus, then we have a simple transition where the *Soh* of the old key is turned into the *Doh* of the new key.

This is the commonest of all transitions. Next in frequency is the transition which makes the old *Fah* into the new *Doh*. The one is called the ***first sharp remove***; the other, the ***first flat remove***. The evolution of the process may be shown by taking our old Modulator for a centre, and writing a couple of little modulators by its side, the one having its *Doh* opposite the *Soh* of the centre modulator, the other having its *Doh* opposite the *Fah*.

d'	f'	
t	m'	l
l	r'	s
s	DOH'	f
	TE	m
f		
m	LAH	r
r	SOH	d
		t_1
d	FAH	
t_1	ME	l_1
l_1	RAY	s_1
s_1	DOH	f_1
	t_1	m_1
f_1		
m_1	l_1	r_1
r_1	s_1	d_1

Here we see at once an explanation of the terms "first sharp" and "first flat" remove. When the old *Soh* becomes the new *Doh*, the old *Fah* has to be sharpened (raised a "little step") in order to create a new *Te*. Similarly, when a *Doh* is set against the old *Fah*, the old *Te* has to be flattened (lowered a "little step"), that the new *Fah* may come rightly into place.

So much for what may be called the theory of transition. We are now prepared for an explanation of how transition is written. It is an exceedingly simple matter. When the transition is very short indeed, the new tone is written as a Chromatic note—*fe*, *ta*, etc., as the case may be. Thus, the last six notes of the above illustration might be written:

:r |m :s |s :fe |s :— |— ||

But even here, and at any rate in the case of all lengthened transitions, the "better method" is adopted of writing in the new key. The passing over into this new key is indicated by means of what is called, very appropriately, a "bridge-tone." A small note indicates the old key and the usual size of note the new. Thus, if the old *Soh* or the old *Fah* is to become the new *Doh*, the notation will show it in this way: ^{s}d ^{f}d

Our previous illustration would therefore be written as follows:

Key F. Key C.t.
:d |m :-.m |r :d |f :f |m :^{r}s |
|l :d' |d' :t |d' :— |— ||

The indication "Key C" shows the new key which is entered, and the "t" following it points out the name of the new sound not in the old key which it is necessary to introduce. Similarly, if we pass from the key of F to that of B flat, as here:

Key F. f.Key B♭.
:d |r :m |f :l |s :— |— :$^{d'}$s |
|f :m |r :d |t_1 :— |— ||

the "f" at the left side of the new key-name shows that *Fah* is the sound that was not in the old key. This pointing out of the new tone is entirely for the guidance of the singer's ear. And, indeed, in the letter notation, it is the singer's convenience that is consulted first. Thus, at the return to the former key, the bridge-tone is always placed at the point where it can most readily assist the singer, whether that corresponds with the actual theoretical change or not.

It is hardly necessary to say that transition is not always made to a key of one "remove" from the prevailing key. This fact the student can bring home to himself by constructing a modulator, not with one other modulator on each side, but with six or seven modulators on each side, each modulator in its turn taking the previous modulator's *Soh* or *Fah* and placing a *Doh* opposite it. Thus, having set down one modulator on the right side of the centre modulator by placing its *Doh* opposite the old *Soh*, he can deal similarly with the second modulator by placing a *Fah* opposite its *Doh*, and so creating a third modulator. A like process can be adopted for the left side. Each new modulator will represent a new key with a new tone not found in the modulator that preceded it. Well, we often come upon transitions in which the intermediate keys (modulators, let us say) are skipped over, so that the new key may require, not one, but three or four new scale-notes. A single example of this will suffice:

Key C. s.d.f. Key E♭.
|d' :— |t :-.d' |d' :— |— :$^{d'}$l |l :— |t :— |d' etc.

Here is a transition which passes over two keys. The original key, observe, is C. Thus, to reach E flat, we have to skip altogether the intermediate keys of F and B flat. More distant "removes" are much used in modern music, where the tonality has often a tendency to continual shifting.

Now we are in a position to take up the subject of modulation. Most people who know anything at all about music know that there is some distinction between the so-called major and minor modes. Briefly, a "mode" arises from the prominent use of one particular note in a composition. Thus, if a piece begins and ends with *Doh*, and all through has *Doh* as a sort of central pivot, it is said to be in the Major Mode. If, on the other hand, it takes *Lah* for its dominating note, it is said to be in the Minor Mode. The distinctive terms Major and Minor are derived in each case from the third above the dominating factor. The third above *Doh* (*me*) is Major, hence the mode which recognises *Doh* as its "governor" is a Major Mode. In the same way, the *Lah* mode is a Minor Mode, because the third above *Lah* (*doh*) is a minor third.

Formerly, they used to have modes founded on every note of the scale: national folk-songs still survive in the *Ray* and *Soh* modes. But in modern music only two modes—the Major Mode of *Doh* and the Minor Mode of *Lah*—are recognised. The old minor mode of *Lah* was simply the unaltered scale founded on that note:

l_1 t_1 d r m f s l

Thus, we have the Scottish air "John Anderson, my Jo" ending in this way:

:l_1 |m_1 :l_1 |l_1 :s_1 |l_1 :— ||

But the modern *Lah* mode is different. It is partly a concession to the exigencies of harmony, partly a concession to the modern ear, which had got so accustomed to the prevailing major mode, with its-half-tone (*te*) below the key-note, that it did not take kindly to a mode with a whole tone (*soh*) below its key-note. Hence, the *soh* was sharpened so as to make it a semitonic leading-note to *Lah*. The result was:

l_1 t_1 d r m f se l

the *se* taking the place of the old *soh*. But here a new difficulty presented itself. The leap from *Fah* to *Se*—a tone and a half—is by no means an agreeable progression; and so the *Fah* is often raised to make a smoother melodic interval. What shall we call this sharpened *Fah?* It will not do to call it *fe*, for *fe* suggests the first sharp key. So, in Sol-fa it is called *ba* (pronounced *bay*), and to save space is occasionally contracted to *b*. It is a note artificially introduced, remember, having no existence except in connection with *Se* in the minor mode. The final result, then, is this:

l_1 t_1 d r m ba se l

There are thus three forms of the minor scale; two of them diatonic (moving by tones and half-tones), but differing as to the place of the semitones; the third chromatic—that is, introducing chromatic intervals and containing three semitones.

The Sol-faist takes a very different view of the minor mode from the Staff notationist. The latter regards the minor mode as an independent, though "relative," scale; the Sol-faist, on the contrary, regards it as merely another form of the major scale—a "mode" of using the scale of *Doh*. Thus, while the Staff notationist speaks of the separate keys of C major and A minor, the Sol-faist looks upon them as practically one key; A minor, in his view, being merely a "mode" of C major. Hence, in giving the pitch-note of the key, the Sol-faist always places *Doh* first; so that when the Staff notationist says "A minor," the Sol-faist says "Key C, *Lah* is A." In short, the Sol-faist gives the pitch of both *Doh* and *Lah*. To a beginner, the whole subject of the minor scale or mode presents very considerable difficulties; in Sol-fa the difficulties are perhaps rather less than in the Staff. In either case they are theoretical rather than practical.

Mention has been made of "chromatics." These are practically the equivalents of the accidental sharps and flats of the Staff. Composers, says Mr. Curwen, often use an effect which is derived from the pleasure that the ear takes in transition. They introduce a *fe* or *ta*, or some other note which leads us to expect a transition, and instead of changing the key, they contradict their intention and remain in the original key. If *fe* is the new tone in a "sharp" transition, it is manifest that if *fah* follows it immediately the old key is reaffirmed, and *fe* blotted out. So when *ta* is the distinguishing note, if we pass on to *te* we reassert the old key. This treatment is called "chromatic," to distinguish it from "transitional," though it must be observed that there are chromatics which do not necessarily even suggest a change of key.

In the Sol-fa notation the names for the sharpened and flattened notes of the scale are shown here, first in ascending, and then in descending:

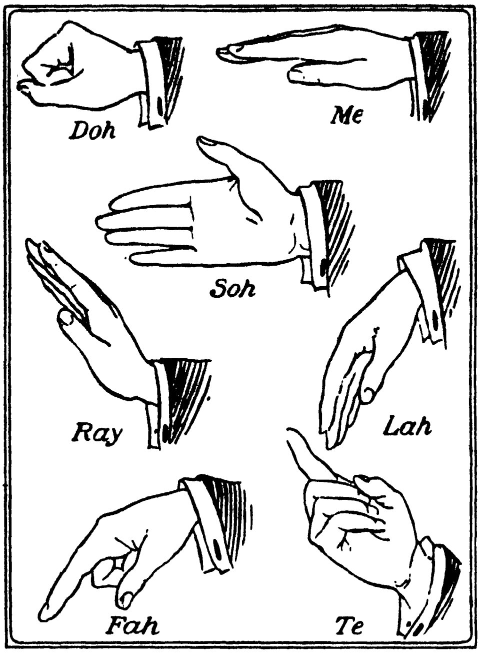
d de r re m f fe s se l le t d'

d' t ta l la s fe f m ma r ra d

It is necessary, of course, to write these chromatic notes in full, so as to distinguish them from the corresponding diatonic note.

Thus far we have dealt with Tonic Sol-fa chiefly as a notation. But it is much more than that. Sol-fa has a *method of teaching* which is, in several respects, peculiar to itself. For instance, great stress is laid on the mental or emotional effects of the individual notes of the scale. *Doh* is recognised as firm and bold; *Soh* as bright and trumpet-like; *Me* as calm and restful; *Lah* as sorrowful and wailing; *Fah* as desolate and awe-inspiring; *Ray* as rousing; and *Te* as shrill and piercing. Great pains are taken by Sol-fa instructors to impress these emotional effects on the minds of pupils, and practical experiment is every day proving that their recognition is a very great help to the correct singing of the notes. Of course, the effects described apply strictly only when the notes of the scale are sung or played slowly. A quickly moving rhythm and certain forms of accompanying harmony may each greatly modify the individual effects. Thus, the minor mode, which sounds sad and solemn in a measured movement, may be made to sound quaint and jovial when sung rapidly.

Out of these mental effects may be said to arise another special feature of Sol-fa teaching—namely, the use of manual signs for the various notes of the scale. Thus, every manual sign endeavours to suggest the emotional characteristic of the tone for which it stands. The clenched fist typifies the firmness of *Doh;* the restfulness of *Me* is indicated by the flat palm; the rousing character of *Ray* by the raised



MANUAL SIGNS

palm; and so on. These signs, which we here reproduce by permission of Messrs. Curwen & Sons, are much used in popular classes, either when the teacher desires to remind his pupils of the mental effects just described, or in voice exercises, when it is desirable that the singer's attention should not be distracted by having to look at book or modulator. A system of manual time-signs is much less used.

A third-feature of Sol-fa teaching is the separate study of tune and time. Tune is taught first from the modulator, and then time is taught by itself, largely by means of a set of "time-names," the improved invention of a Frenchman, M. Aimé Paris. It would occupy a great deal of space to give a complete list of these time-names, with the corresponding notation. The following illustration introduces the rhythmical forms most frequently met with:

d :m	s :—	s .m :l .d'	s :—
Taa Taa	Taa - aa	Taa Tai Taa Tai	Taa - aa
m :– .f	r :d,t,.d,r	m :	
Taa - aa tai	Taa ta fa te fe	Taa Saa	
s :m	d',s.m :d ,m.s	d :— ‖	
Taa Taa	Ta fa Tai ta fa Tai	Taa - aa	

In applying these names to his early exercises, the Sol-fa pupil sings them *on one tone* till he has mastered the time, and only then does he try to combine the time with the tune. The value of the method for beginners is obvious. It gives them a confidence which they could not possibly acquire so soon in any other way.

Much more might be said about the Sol-fa method of teaching if one had "ample room and verge enough." Mr. Curwen has admirably summed it up in a few words: "To let the easy come before the difficult; to introduce the real and concrete before the ideal or abstract; to teach the elemental before the compound, and do one thing at a time; to introduce, both for explanation and practice, the common before the uncommon; to teach the thing before the sign, and when the thing is apprehended attach to it a distinct sign; to let each step, as far as possible, rise out of that which goes before, and lead up to that which comes after; and lastly, to call in the understanding to assist the skill at every step." These principles find their most exhaustive explanation in "The Teacher's Manual of the Tonic Sol-fa Method."

In studying *harmony* [see THEORY OF MUSIC] the Sol-faist uses a chord-naming notation of his own. In the Staff the chords are indicated by a system of figured basses. In Sol-fa the nomenclature corresponds in simplicity with the notation of tune. Each chord of the scale is named by its Sol-fa initial letter, printed as a capital, as here:

m	r	d	r	m	
s	t	l	l	l	
d	s	f	f	d	
d	s	f	r	l	
D	S	F	R	L	etc.

In the minor mode the chord capitals are printed in italics. Chords in their direct form—that is, with the root in the bass, are said to be in the *a* position, but in the nomenclature the *a* is always omitted. The further positions (inversions) are indicated by the letters *b, c, d,* etc., as the case may be. Thus:

d	m	s	r	
s	s	r	t	
d	d	s	s	
m	s	t	r	
Db	*Dc*	*Sb*	*Sc*	etc.

The minor dominant chord—m, se, m, t—is known as ^{se}M. When a seventh, a ninth, or a fourth is added to a chord (remember that a common chord consists of root, third and fifth), the fact is indicated by a little figure at the upper left-hand side of the chord-name:

^7S ^4S ^9S etc.

Passing notes, again, are indicated by an italic *p* printed under the chord-name—*p* only when the passing note is dissonant, *cp* when consonant.

Such are the general principles of the Sol-fa notation and method of teaching. For minute details it is necessary to consult the published manuals and treatises of the Tonic Sol-fa Press, in particular "The Standard Course of Lessons and Exercises in the Tonic Sol-fa Method of Teaching Music." The Staff notation musician who desires to study the notation in comparison with and from the special point of view of his own notation should see "Tonic Sol-fa," by John Curwen, in Novello's "Music Primers" series.

Tonic Sol-fa Concluded

Continued from page 806.

CYCLOPÆDIA OF SHOPKEEPING

BABY-CARRIAGE DEALERS. The Buying, Stocking, Selling, Hiring, and Repairing of Baby Carriages. Profits of the Trade.

BABY-LINEN OUTFITTERS. The Capital necessary, and the Method of Spending it. The Shop and its Accessories.

BAG AND TRUNK DEALERS. The Shop-Fittings and Stock. Details of Purchasing. Profits.

BAKERS AND CONFECTIONERS. Technical Instruction. Bakehouse Plant and Fittings. The Shop and its Requirements.

BABY-CARRIAGE DEALERS

The vendor of baby-carriages seldom confines himself to their sale. Occasionally they may constitute the backbone of a business, but more often they are merely a branch of a more important trade, such as that of the ironmonger, the house furnisher, the cycle or sewing machine agent, or the draper. As the trade, under British climatic conditions, is strictly a season one, the vendor of baby-carriages pure and simple finds nothing to occupy him during the winter months, so that his profits and turnover during the selling season must be fairly large to permit successful trading upon such a basis. There are some classes of shops with which the sale of baby-carriages goes well—as, for instance, that of a domestic laundry machine depôt, which has its busiest period during the winter months. The summer trade in baby-carriages equalises business somewhat. On the other hand, it is an awkward adjunct to the business of a cycle agent, as both departments are under pressure and both dead during the same months of the year.

Stock and Stocking. The stock takes up a good deal of room, hence the trade can be conducted properly only by the shopkeeper who possesses the necessary accommodation. The small ironmonger or draper whose shop and warehouse are closely packed with goods more necessary to his proper business should leave the selling of baby-carriages alone. The articles deteriorate easily from the scratching inevitable when they are mingled with miscellaneous merchandise, and this takes all the gilt off the gingerbread.

The sum of £50 will put in a very good stock of baby-carriages, and less than half of this sum will suffice if it be merely a department of another business. The dealers usually order season's stock in February, receiving delivery some time in March, and selling begins shortly before Easter. A good and well-assorted display should be made at the opening of the selling season, but great care should be exercised in repeating stock when it is sold, as very little is done after August. A few carriages may be sold in September, but from October to March the articles may be packed away out of sight. A shop with an open window is the best for the dealer. It permits street passengers to see the assortment, and the parents—especially if baby be the firstborn—are most particular in their choice.

Fashion. Fashion must be studied, especially by the man new to the business. It is rather easy to put in unsaleable or slow stock. Above all, expensive carriages should be ordered sparingly. The cheap article is that in which the bulk of the trade is done. The last few years have witnessed a wave of popularity for the light, collapsible baby-vehicle, termed the go-cart, or push-cart. This is not good for the infant occupant, and bad for the trade. It will not accommodate the infant in a lying posture, and it is not desirable that a very young child should sit erect for hours. Also, this type of baby-carriage is not more than half the price of the larger article, and therefore carries only half the profit. The dealer should always point out the disadvantages of the go-cart in comparison with the larger bassinette, or perambulator. If he makes a practice of doing so, he will probably succeed in selling the more expensive vechicle in every other instance. Go-carts may be retailed as cheaply as 10s., but the usual selling price is from 15s. to 25s., showing a profit upon selling price of 33⅓ per cent., or a little more. This type of vehicle is in diminished favour, but it will always have a certain acceptance by the flat dweller, who finds every square inch of house-room a matter of consideration, and by the parent who migrates to the seaside. The latter may transport it thither, and thereby save the expense of hiring a baby-carriage during the holiday.

Bassinettes. The bassinette, properly so-called, is a child's vehicle with a basket body, although the word is usually made more comprehensive. Bassinettes proper came into fashion a few years ago, and are gaining in popularity. The bodies were originally all imported from America and Canada, but English cane-workers have taken up the trade, and now very few bodies are of foreign manufacture. Bassinettes are usually more expensive than those with wooden bodies. We have seen them retailed at 35s. by cutting drapers, but the articles had the poorest bodies possible to mount on wheels. The mail-cart form of baby-carriage is also made extensively with a basket body, but the trade is not so great as it is in the larger vehicle.

Prices. Makers' lists are usually subject to 50 per cent. discount, although a few firms, chiefly high-class manufacturers, frame list prices upon a more moderate scale, allowing correspondingly smaller discounts. Also, 5 per cent. extra may be secured for cash payments, which should always be taken, even if difficulty be found in paying promptly. The large discount does not mean that the dealer secures

50 per cent. profit. He has usually to allow fair discounts to the purchaser, up to 20 per cent. Still, the profits possible are good. When drapers take up and push the department they usually play havoc with profits of more legitimate traders in their neighbourhood, but very frequently the draper sells only very cheap stuff, leaving the better trade to others.

A fair proportion of the trade in baby carriages is a cash trade, yet payment by instalments is becoming every year more common. But the trade wisely refuses to admit purchasers of low-priced goods to the advantages of gradual payments, for the simple reason that such goods might be worn out before full payment had been made. Full list prices, bearing the profit of 50 per cent., should be secured on all instalment business, and even so it does not pay exceedingly well. It demands the careful watching of each individual account.

Other Departments. A natural branch of a baby-carriage department is the selling of baby-chairs. There is always a steady demand for those of the three position type, of which Plant's patent was the pioneer. They yield profits similar to baby-carriages. Rocking-horses and children's toys are also frequently added, and should always be so if baby-carriages be the main department, as toys form a good winter trade, especially at Christmas-time. Bath-chairs also usually fall to the baby-carriage dealer, but their sale is exceedingly limited, except in watering-places, and it may be well to avoid stock.

Selling. The dealer who makes baby-carriages a prominent department should strain every effort to be looked upon in his neighbourhood as the leading man for such goods. The trade is particularly susceptible to influence by advertisement in the local newspapers. We have known excellent results attained by the practice of posting a neat price list and circular to the addresses given in the birth columns of the local press.

Repairing. The repairing of baby-carriages is not an extensive trade, but it is exceedingly remunerative. The stock necessary for its prosecution is not large—an assortment of indiarubber tyres, a few brass axle-caps, and some handles, being almost all that is necessary. Tyre-fitting pays well. The rubber tyres may cost not more than 10d. per pound, and a charge of 5s. or 6s. for fitting four wheels with new tyres will show a profit of half the price, even allowing for the labour of fixing. A new form of tyre with a wire centre has the double advantage that it is bought in coil, so that an assortment of sizes need not be kept, also that it may be fixed without heat, thus avoiding injury to the painted rims. When baby-carriage repairs include painting or upholstering, they have usually to be sent to other tradesmen to be done, as the dealer is seldom sufficiently expert in either work. In such cases smaller profits must serve—say, 25 per cent. upon the total charge.

Hiring. The hiring of children's vehicles is common, especially in summer resorts. It is remunerative, but charges vary, so that no general estimate can be given. Perhaps 2s. 6d. to 5s. per week may be accepted as an average price for an article costing 40s. to 50s. Hiring charges should be framed so that the cost price of the article is recovered by a season's hiring of, say, four months.

BABY-LINEN OUTFITTERS

A Woman's Sphere. The vending of baby-clothes is essentially a woman's occupation. It has many attractions for womankind, and especially for those who have known the joys of motherhood. It is an ideal occupation for a widow with only a small capital, and if she has any business ability, it can be made not only the means of a livelihood, but even of securing a competency. Many married women with business aspirations start a baby-linen shop in order to augment the income of a delicate or otherwise unfortunate husband, and the woman with tact, taste, and ability "to use her hands," invariably succeeds.

Capital and Shop. With a sum of £100 to £150 in hand, a fairly advantageous start may be made, the neighbourhood selected being, for preference, a popular residential one. A main street is not essential, unless the adventuress has ambitions beyond a merely family business. The trade is primarily a personal one, and a suitable shop should be chosen in a neighbourhood where mothers and children abound. The shop need not be large; in fact, it should be small, with living-rooms attached, nicely painted, and kept scrupulously clean and neat. The fittings should include a counter with a glass top (many of which may be picked up secondhand for about £5), several dummies of children at various ages, a few brass uprights of different lengths for displaying bonnets, hoods, cloaks, etc., and a brass stand with glass shelves. One side of the shop might be fitted with wood shelving for the various articles that come in, and to carry cardboard, millboard, and cloth-covered boxes of useful sizes, that are necessary for stocking small goods. A large mirror should also be provided. The window should have upright fittings, with brass movable arms projecting on either side. A sum of £15 ought to cover the cost of the entire fittings.

The Stock. The requirements for a baby-linen business are, broadly, all the articles of apparel necessary for a child from the moment of its birth until it is three or four years old. First of all, there is the layette. This includes infants' shirts, long day flannels, night flannels, longcloth petticoats, daygowns, nightgowns, woven cotton swathes, flannel swathes, diapers, Turkish squares, flannel squares, woollen boots, robes, cloaks, and hoods. The next—technically known as the "shortening"—stage is provided for by a supply of short frocks (made of nainsook, India twill, silk, or cashmere), bibs, cambric or longcloth slips, pelisses (in serge, piqué, or marcella—plain, trimmed, and embroidered), pinafores (nainsook and lawn), white and coloured wool socks and bootakins, and infantees (or fingerless gloves) in Lisle thread, silk or wool. For older children provision must be made by an assortment of walking-costumes, sleeping-suits, knickers, spencers, overalls, and gaiters of cloth and wool, not forgetting petticoats, chemises, and nightdresses.

An Opening Selection. One advantage this business has over general drapery is in the fact that there is no variety in sizes. The garments are mostly all of one size, and a beginner who is wise will not have a great variety of any one article. To the inexperienced every help is given by the wholesale baby-linen houses, any one of which will supply a complete assortment to suit all classes. It is not advisable, however, to leave matters entirely in the hands of the wholesale house. The endeavour should be to work as much as possible on sample lines at first, gradually increasing the stock as the business grows. The clever woman will make her stock as much as possible at home. At any rate, she should cut out and plan herself, and in these days of universal sewing machines the work can be run together by an assistant. She should buy pieces of flannel, nainsook, or longcloth, and cut them up to the best advantage. Therefore, with the majority of articles, the opening order should be for one sample of each, unless, of course, in the case of cheap things, such as swathes, woollen boots, diapers, and so forth, several of which are required at once by each customer. About £5 would be spent on a variety of robes and monthly gowns, and a similar sum on nightdresses and flannels. With such things the best way is to buy six quarter dozens at three different prices, varied according to the class of business. A stock of daygowns would cost £2, of hoods £2 10s., and with another £10 a fine assortment of miscellaneous articles, like slips, swathes, etc., could be obtained. In shortening goods, £5 would be expended on dresses, white and coloured; £2 on pinafores; another £2 on gaiters, stay-bands, petticoats, &c.; £5 on hats and bonnets, and £2 on bibs, spencers, and sleeping suits.

Accessories. There are many little things incidental to the business upon which we have not yet touched. These all tend to swell the profits; they cost little and look imposing. First may be mentioned macintosh goods, such as aprons for the nurse, accouchment sheets, diapers for the mother, sponge-bags, and pilches. An outlay of another £2 on these, and two bassinettes—one trimmed and one not—would cost another £2. A toilet-basket trimmed, and another untrimmed, would not come to more than £1, while a selection of trays, dotted here and there in the shop, with puff-boxes (including a loose selection of powder-puffs and violet powder), babies' hairbrushes and small combs, costs little money, looks well, and generally draws the purchasing parent. The hairbrushes, puff-boxes, etc., are made of pearl, ivory, celluloid or bone. Then, baby-linen and ladies' underwear invariably go together in the big drapery houses, but the beginner would not be able to launch out strongly in that direction at first. However, it might be found expedient to spend £15 on nightdresses, chemises, camisoles, and combinations for young girls and ladies, and by-and-by these might be augumented by a select assortment of dainty underskirts, knickers, nightgowns, corsets, dressing-gowns, and tea-gowns. Taste and neatness in window and in internal shop display is necessary. The window should be lightly dressed, with not too many articles displayed, and it should be dressed daily. A few of the dummy children arrayed in all their glory are usually placed at the back. Hoods, dresses, and coats could be dotted here and there about the shop on the stands aforementioned.

The Question of Profits. Drapers generally concede that baby-linen is one of their best paying departments. Experience in drapery is a help but not an actual necessity to make a success as a baby-linen vendor pure and simple. Provided the woman who essays to make a living at the trade has a fairly level business head, an average profit of from 33⅓ to 40 per cent. is possible. A bonnet selling at 3s. 11d. would probably cost 2s. 6d.; pelisses costing 3s. 3d. sell at 4s. 11d. Towelling at 3s. per dozen, on the other hand, would perhaps have to be sold at 3s. 11d.; but, taken all in all, the profits are as stated. It must not be forgotten, either, that a woman "handy with her fingers" can make many things, such as babies' bonnets and dresses out of next to nothing, and thus swell the total profit. A smart woman will turn over her stock six times a year. Her expenses in a small shop such as we have sketched (rent, £40; rates, £10; gas, £10; and errand boy or girl, £20) would be about £80, so that if she started with £80 stock, turned it over six times a year and made an average profit of 33⅓ per cent., she would be £80 in hand at the end of the year. This is calculating on good, straightforward trading, but the beginner whose net profit at the end of the first few years does not come up to that sum, or even the half of it, need not necessarily be discouraged. The same buying terms and credits apply to this as to the drapery trade.

BAG AND TRUNK DEALERS

In large cities the selling of bags, portmanteaux, and trunks may be a special business, but in smaller towns the trade is usually allied to the ironmongery, drapery, or house furnishing trades. We may consider first the capital and equipment necessary for a distinct bag and trunk dealer in a prominent city thoroughfare.

Premises and Fittings. The shop must be fairly large, as the stock is bulky, and a first-class trade in London demands premises with a rental of £350 to £500 a year. The fittings are expensive items. They must be good and up-to-date. The front window ought to be enclosed and dustproof, with plenty of movable glass shelves and brackets. Its cost would be about £25. The side farther from the door may be fitted with a large plate-glass mirror. A large wall-case about 6 ft. high is a desirable part of the equipment, and should also have a silvered glass back. The cost of this would be about £30, but if this sum be considered too heavy a charge, black paper may be used for backing. It is the material next best for showing up the goods displayed. Then £25 might well be spent upon a counter-case with glass sides and ends, with plate-glass top, and with movable glass shelves. All woodwork should be black, for the reason already given. The shelves may be of deal, painted black. For trunks, suitable racks may be made of ordinary gas tubes—say, three rows of two pipes, supported by wooden uprights, provided with holes to allow the horizontal tubes to be changed as required. The ceiling whitened and the walls washed in a blue-grey colour, plain linoleum over the entire floor, a few good rugs, and six black bent-wood chairs will complete the decoration and the fittings, at a total cost of about £100. Electric light is the best illuminant, as it allows the goods and the shop to remain fresh longer than gas, but the latter should be laid on for emergency use.

Capital and Staff. The trader beginning in the manner we suggest must have not less than £500 capital. Our scheme of fittings and decoration has left him rather less than £400 for stock, not a penny too much. Wholesale merchants or manufacturers will, if they know their man, accommodate him by giving three months' credit and allowing full cash discount. Even so, it may be necessary to grant bills for part of the stock account, especially if business moves somewhat slowly at first, but it is better to mortgage the future thus than to deplete entirely the bank balance, because rent, taxes, and current expenses are steady periodical charges which may not wait for settlement.

The only shop assistance required by the beginner would be a boy fresh from school, at 5s. or 6s. a week, and a porter at 20s. a week to do packing and unpacking, cleaning and sweeping, and to carry home purchases.

Profit. The profits in the trade are good, seldom less than 33⅓ per cent. upon turnover, which means 50 per cent. upon invoice prices. More may often be had. Gladstone bags costing 7d. or 7½d. an inch may be sold for 11d. or 1s. an inch, and as stock can usually be replaced quickly, it may be turned over three or four times a year.

In the larger articles of sale fashion does not change much, and the stock is not apt to become soiled, hence there is little loss by depreciation. In fact, a trunk or a leather bag that has lost its pristine freshness without having become damaged is often preferred by the purchaser.

Bags. Besides kit-bags, square bags, gladstone bags, and brief-bags, stock must be kept of many varieties that come under the general heading " bags." Small fancy bags for ladies' shopping are in good demand. Bags to hang from the waist, from the plain 1s. article to artistic patterns in coloured leathers, are also much sold, especially when shown, as they make acceptable presents. They must be stocked in many colours, to match the dresses of the wearers, and retail as high as 50s. each. Courier, brief and square bags, gladstone and kit bags, should be in a nice nut shade of brown cowhide, and it is well to show them in sets ranging from the smallest to the largest. All may be kept in three qualities, the best lined with leather, tan-coloured for preference. Black leather bags have a very limited sale, and the stock of them should be small.

Fitted Bags. Fitted bags for ladies should be stocked from 21s. upwards. The cheaper qualities are usually in black roan leather, and the better varieties, from 63s. upwards, in tan hide, lined with red leather, and fitted with ebony brushes and silver-topped bottles. A special line is often made of ladies' fitted bags, at 5 guineas, in varieties leather lined with watered silk to match, or to contrast with the outside. At higher prices—say, 7, 8, and 10 guineas each—one of each kind will suffice for stock. Large, cumbersome bags are not now wanted. The usual sizes are 12, 14, and 16 in., with the 14 in. in greater demand. Fitted bags, combined for man and wife, may also be kept, although they sell in smaller quantities than those mentioned. Suit cases, fitted bags for gentlemen, and " Saturday to Monday " bags are also necessary in several varieties and qualities similar to the stock of ladies' fitted bags. By purchasing the fittings direct from the makers and not from the manufacturer of the bags quite 10 per cent. may be saved, and the fittings may be arranged to the individual taste of the seller, who may thus always have something different from the articles being sold by his competitors.

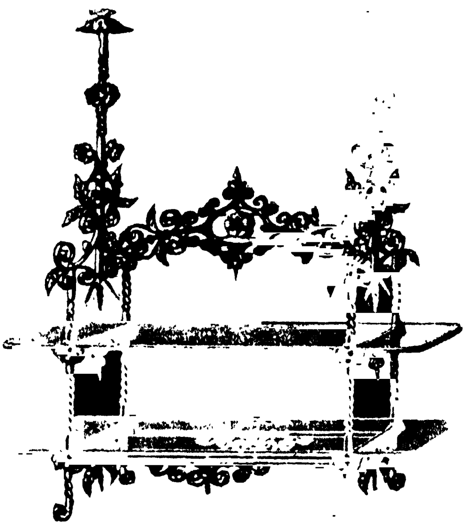
Small holdalls for ladies' use, 24 in. wide, to sell at 5s , 27 in. at 5s 9d., 30 in., 7s. 6d., should be a cut line, and be made of smart tweeds, with brown leather bindings, straps and handles. Better patterns, to sell at 10s. 6d., and larger sizes at about 21s., for gentlemen's and family use, should also be in stock.

Other wares necessary for stock include dressing-cases for both ladies and gentlemen—the cheaper qualities bought direct from Germany, and the better made up, similar to the fitted bags already described; dress-baskets, in sizes from 24 to 36 in., selling at 1s. to 1s. 6d. per inch; shallow dress-baskets, in two sizes, 39 and 42 in.; gentlemen's hat-boxes, from the light basil article, retailing at 12s. 6d., to the light-weight solid leather variety, with places for straw, bowler, and silk hats; bonnet boxes in good variety, from the cheap design covered with American cloth, and selling at 3s. 6d. to 7s. 6d., to the leather-bound style, with four and six wire cones, retailing at 12s. 6d. and 21s. respectively; holdalls and rug-straps; and, finally, gun-cases, cartridge-cases, and game-bags.

Small Wares. In the smaller articles, all of which are remunerative, purses are the most important. They have a steady sale. The humble shilling article must not be neglected, as it is a favourite. Prices range up to 30s., at which figure they should be mounted with 9-ct. gold. Most purses are of foreign manufacture—the cheap, useful kind, German; the best, Austrian, from Vienna; only the pigskin and some others, in which strength and not elegance is the prominent feature, are made in England.

Letter and card cases, cigar and cigarette cases are always in request for presents, and just before Christmas-time stock should be heavy, as delay in having orders for new stock fulfilled is common. The favourite price for a letter-case is 2s. 6d.; for a card-case, 1s.; for a cigar-case, 2s. 6d.; and for a cigarette-case, 1s. 6d. The better qualities should be kept in such leathers as long-grain Morocco, shark, lizard, and sealskin, elephant, and crocodile. The favourite leather is golden crocodile, either dull or polished. The additions of monograms to these goods is remunerative. Other articles in this department include dog-leads, collars, and whips, whistles, watch bracelets, collar, tie, stud, and jewel boxes; leather luggage labels; tourist, writing, and music cases and portfolios.

Trunks. Most dealers in leather goods whose stocks we have been reviewing leave to the ironmonger the sale of steel trunks, holding them to be out of place among the leather goods. This can be done without much regret, as they are less remunerative than the goods which the bag and trunk dealer handles. Steamer trunks are an important item. The length may be from 30 to 42 in., but the height should not exceed 14 in., as this is the limit allowed by some steamship companies. The best varieties are made of compressed cane, but this material is finding a serious rival at little more than one-third the price since the introduction of trunks of three-ply wood. Steamer trunks are not usually sold fitted with a tray, but customers appreciate the convenience of this accessory, and the trader who carries stock so fitted is well advised. Many other styles of steamer trunks are made, the cheaper being of wood covered with canvas and strapped. Overland and imperial trunks are made, and must be stocked, in similar variety to steamer trunks, including the P. & O., Orient, and troopship regulation size trunk. If in London, samples of bullock and transport trunks may also be held.



1. ARTISTIC WINDOW FITTING

Added Departments. We have indicated briefly the nature of the stock of a general bag and trunk merchant who would hold a representative assortment of the goods he professes to handle. As business grows, and as funds permit, he may add other wares—such as small silver and ivory articles, nicknacks, clocks, thermometers, games, and playing-cards, sundries usually associated with the stationery trade, such as fountain and stylographic pens, gold and silver pencil-cases, letter balances, and photo frames, especially those for the pocket; also fans, flasks, picnic and tea baskets, walking-sticks, and other objects suitable for presentation. Articles which naturally fall in with the trade are fittings for bags, such as combs and brushes, razors, pocket-knives, and scissors.

Repairs. The repairing department may be made exceedingly profitable, and, if possible, a man should be retained on the premises to execute the work, promptness being usually the essence of any repair job. Initials should be stamped on all leather goods bought, and painted on trunks, without charge. If stock of silver letters be kept for finer articles, they may be fixed while the purchaser waits. They may be bought at 3s. a dozen, and sold at 6d. each. Larger ones cost 6s. a dozen, and sell at 1s. each. Silver monograms may be bought for 1s. 6d., and sold at 2s. 6d.

Terms of Selling. From its nature this trade is principally of a cash description, as the chief customers are travellers, many of them *en voyage*. Credit must, however, be given sometimes to residents in the neighbourhood. Some months bring much business, and some are very quiet. The best time of the year for London dealers is from August to October. The starter should open shop in June, as he may thus take early advantage of the busy time.

As a Side Line. We have depicted the bag and trunk merchant who begins business in a good street in a large city. In a smaller city articles of a cheaper class than many we have described are more suitable. There are always specific factors which no general article can take into calculation. The ironmonger, draper, saddler, or other tradesman, who would embark in the selling of bags and trunks as a side line, would do well to invest capital only in such goods as steamer, overland, and imperial trunks, gladstone, square kit, and brief bags, holdalls and rug-straps, and enlarge his scope as he gains experience. He should always have on hand priced catalogues, showing particulars of the other articles we have mentioned, in order not to lose the opportunity of selling from the list should occasion offer.

BAKERS AND CONFECTIONERS

The business of a baker is essentially one where manufacturing skill and commercial ability must go hand in hand to the attainment of success. An average degree of both qualities will yield better results than an excess of the one and a conspicuous lack of the other. The man whose knowledge of the art of baking enables him to excel on the practical side will fall far short of high success unless he unites with this practical ability the commercial ability to adjust expense to output, to market his products efficiently, and to see that the profit-sucking leeches of waste in manufacture, distribution, and the collection of accounts finds as small a hold as possible upon the organism of his enterprise. Many of the cautions necessary for observance by the successful baker are those essential in any department of commercial activity, and it is not our intention to put stress upon them here; but for the discussion of the requirements peculiarly pertaining to the baker and confectioner this is the fitting place.

Scientific Baking. The establishment of baking upon the scientific basis which is becoming more and more the foundation on which the fabric of the industry rests in this country may be said to date from the Healtheries Exhibition, held in London in the year 1884. At that function attention was first prominently drawn to the possibilities of machinery in bakehouse economy, and, like yeast in the dough, a ferment of unrest began to operate in the trade corpus, requiring for its satisfaction the introduction of the best baking plant which engineering skill and an appreciation of the ends to be attained made possible. Then one could see on all sides bakers' shops with the legend "Model Bakery" or "Steam Bakery," indicating that precedent had been neglected and modern scientific methods introduced. These signs are to be seen less frequently now. Establishments where they might be exhibited have become almost the rule, not the exception.

2. INTERIOR OF BAKER'S AND CONFECTIONER'S SHOP

Technical Education. The first essential to a successful baker is a knowledge of baking. Such a statement may seem to be entirely gratuitous and superfluous, but it is not so. By a knowledge of baking is meant not merely the experience gained by years of practice between the dough trough and the oven, and an acquaintance with only the mechanical side of the business, but the much higher skill in which science is wedded to practice and the reasons for processes are understood as well as their manifestations. The scientific side of baking is receiving attention as never before. The National Association of Master Bakers and Confectioners has co-operated with the Borough Polytechnic Institute in the Borough, London, S.E., and they have spent thousands of pounds sterling in facilities where the rank and file of the trade may acquire a thorough technical knowledge of bread-making. In the institution mentioned there is the only permanent college of baking in the United Kingdom, and every aspirant to success in the business of baking should take advantage of the opportunities offered. There are two large bakeries, equipped with modern machinery and appliances, and practical instruction in both bread-making and confectionery is conveyed. Other subjects which may be studied under competent professors include chemistry, physics, biology, and drawing and modelling, all in their relation to the manufacture of bread and confectionery. The school session lasts from September to May. The most rapid progress is to be secured by attending the day classes, held between the hours of 9 a.m. and 4 p.m. It is found that day students are recruited almost exclusively from the sons of master bakers. For those whose vocation compels them to be employed during the daytime, evening classes are available on two days a week for each subject. Both classes of students must sit for the official examinations held by the City and Guilds of London Institute in conjunction with the National Association. The class fees for day students are £6 6s. per session and for evening scholars 7s. 6d. for an elementary course and 10s. 6d. for an advanced course in either class.

Provincial Instruction. The undoubted success of the National School of Baking and Confectionery in London has inspired provincial centres with the ambition to offer similar facilities for the study of the art of bread-making. The sum of about £5,000 has been raised to found a school of baking and confectionery in connection with the Glasgow and West of Scotland Technical College. The institution of the school has not yet been accomplished, but it cannot be long delayed. Evening classes, confined to those engaged in the baking trade, are held in many provincial towns, including Manchester, Belfast, Hull, Liverpool, Bristol, Ayr, Hamilton, Kilmarnock, and Glasgow. In addition to these the professors at the National School visit selected towns during the summer months, secure a bakehouse and open classes for bakers in the district. The session at these summer classes lasts usually from 5 to 8 weeks, with two days' instruction in each week. Thus, while some towns are more favoured than others in the opportunities for bakers to receive instruction in the science of their craft, the agencies are fairly well distributed, and scarcely a baker in the country would be unable to take advantage of one or other of them if the desire were keen.

The Bakehouse. This is not the place for any technical digest of the principles of bread-making, which will be treated in another part of the SELF-EDUCATOR. The commercial side of the business only lies within our province, and in reviewing the baker's equipment we shall begin with the bakehouse. The technically-instructed tradesman naturally wishes to instal the appliances which will give scope to his scientific knowledge, and assuming that he must study economy in his disbursements he may be recommended to invest in an outfit of the following details.

1 Peel oven.
1 Flour-sifting machine.
1 Dough-mixing and kneading machine.
1 Gauging and tempering cistern.

3. CONFECTIONERY DISPLAY STAND

These items will cost him about £150, in addition to which he must bear the cost of preparing the brick foundation and chimney for the oven, unless, indeed, he is fortunate enough to secure as a bakehouse a building in which these are already fitted. Some bakers' outfitters are willing to quote for, and undertake, the whole installation, including any necessary bricklaying, and it is often the wiser course to allow them to do so. A permanent oven built in the usual manner becomes, of course, a landlord's fixture, and the tenant can neither remove it nor demand any consideration for it upon the expiry of his lease. Should the tenant, however, take the precaution to have one layer of timber placed below the oven, but over the foundations, he will thereby reserve to himself the liberty to remove the oven whenever he may wish, as this provision prevents the structure from being considered a permanent fixture.

4. SHOP-RACK FOR SMALLS

The wisdom of acting in this way does not lie in the value that would attach to the oven, should he decide to remove it, but in making the landlord less liable to seek to increase the rent upon any renewal of the letting term.

The baker may save £50 of the outlay suggested above, if he will content himself with a portable oven, but unless there are stringent reasons for so doing he will be wise to give the larger sum for the more permanent article. His sundries, including two dough-tables, a dough-trough, a bread-rack and a complete equipment of utensils will increase the bill by £25.

Some expenditure will be occasioned by the confectionery department, into which, it may be assumed, our baker will also venture. A sponge-whisk will cost about 21s., and a full assortment of tins, moulds, pipes, and all the necessary utensils may be put in at a cost of from £10 to £12.

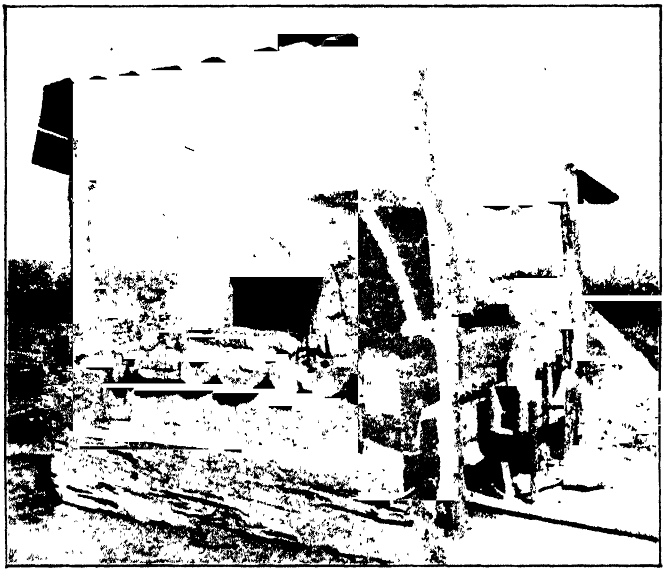
A small power whisk would cost £3 3s., and a cake machine £20, but these would be an unnecessary expense until the confectionery trade had developed very much indeed.

Output. A plant such as we have sketched will permit an output of 15 to 20 sacks of flour per week, including £6 worth of smalls and confectionery. Even 25 sacks might be put through, but this would be difficult, and could scarcely be maintained. The limit is reached, not by the machinery, but by the oven. The machines we have mentioned could be worked up to the baking capacity of two ovens, hence, doubling the capacity does not double the cost of the equipment. This is a detail which illustrates how the larger producer can often compete against the smaller man upon more favourable conditions.

Assistance. We have assumed that our baker commencing business is to be his own chief workman. There is small chance of success otherwise. An enterprise on such a scale would be unable to support a proprietor who did not earn a workman's wage by labour in his own bakehouse or by delivering his bread. He would want a man, whose wages would depend upon locality. London bakers earn 25s. to 30s. per week; bakers in the English provinces 24s. to 28s. per week; but in Scotland higher rates are common, and the average may be taken at 32s. a week. A foreman baker in a small bakehouse earns about 5s. more than an ordinary hand. A youth as improver may be had at

15s. a week in London, or at 10s. a week in the provinces. He will be useful outside the bakehouse as well as in it, and may do the customers' rounds with board, barrow or cart. But the small baker should never trust entirely to his improver, but should take care to come into personal contact with his customers periodically. Thus he may receive complaints, learn the wishes of the customers, and check the accounts owing, if there be such, for a youth entrusted with the handling of money is often tempted to appropriate it, a practice which usually begins in borrowing.

Buying Flour. There is great competition among the millers for the custom of the baker, hence there is no uniformity in the terms upon which he is required to pay for his flour. Payment at one month under discount of 1¼ per cent., or 6d. per sack, is not uncommon. Larger credit is usually net, or with added interest proportionate to the credit. But millers frequently run over each other in attempts to secure orders, and, as a matter of fact, a baker can nearly always get flour, even if he have not a penny to pay for it. This accounts for a good many of the bankruptcies in the trade, for if credit were not so cheap, fewer men with ambition, but without means, would be tempted to establish themselves. In a fluctuating commodity like flour, forward buying under contract is common, also speculative buying, even beyond the consumptive capacity of the individual. The ability to estimate a firmer market is a desirable quality, and its exercise is very profitable, but, of course, the risks are proportionate.


5. BAKING OVEN IN CANADIAN BACKWOODS

Selling Prices. The sack of flour weighing 280 lb. produces from 92 to 96 quartern loaves. The rise or fall of 4s. in the price of a sack of flour is supposed to raise or lower the price of the loaf one farthing. But it often does not do so. There are fools in every trade, and the bakery trade has its proportion. Competition causes many bakers to cut prices below remunerative level, and this not only prevents the cutter from making his proper profit, but also makes his competitors and his neighbourhood work for less than a fair price. It is recognised that the price of the product of each sack of flour should be 14s. in excess of the flour cost. From this 14s. the baker has to pay for his yeast and other ingredients, labour, fuel, and working expenses. Some bakers are content with a gross profit of 10s. per sack, and they may make a living by hard work, but after they have worked themselves to death they will scarcely be able to leave behind them sufficient money to pay for a respectable tombstone.

Upon small goods and confectionery retail prices should be not less than double that of the materials used. The loss upon these is greater; they are saleable only when fresh, and the baker must choose between having on hand a good stock right up till the hour of closing each night, with a consequent certainty of having a good percentage of stale stock, or of displeasing customers by running on short stocks, and, therefore, of being unable to do a good evening trade.

Special Breads. There has been created a good demand for special breads of the Hovis and Bermaline types. In the one, the usual loaf weighs 1 lb. 10 oz., and retails at 3d. In the other, it is usually 1 lb. for 1½d. Such breads pay well—quite double the profits yielded by the common loaf. Their manufacture is very simple. It is necessary only to follow explicitly the directions issued by the firms who own the processes. Very small quantities may be made quite as easily as large quantities, and care should be taken not to make too much, because to have to sell it as stale is to lose all the advantage of the higher profits possible. These special breads stand a much heavier proportion of water than ordinary flour.

Bakehouse Laws. The law imposes certain distinct obligations upon the proprietors of a bakehouse. If machinery be used—and the modern bakehouse fills this condition—the place is subject to the general provisions of the Factory Acts. If the establishment be a retail one, these provisions are enforced by the Medical Officer of Health of the local district authority, and not by inspectors under the Factory Acts. The interior of the bakehouse must be limewashed, painted, and washed at certain specified times, and must not be used as a sleeping-place. No building underground may be used as a bakehouse, unless it was so used prior to January 1st, 1896. Care is also necessary that children and young persons be not employed in a factory, except within such hours as the law permits. The Bread Acts and the Sale of Food and Drug Acts are framed to prevent adulteration. The introduction of alum into bread, for instance, is not permitted, although technical opinion is not unanimous in condemning its use. Many other ingredients may not by law be incorporated in bread, but alum seems to be the only adulterant regarding which action has been taken for some years. The quartern loaf is supposed to weigh 4 lb., but most of the bread now sold is in half-quartern, or 2 lb. loaves. In the present state of the law, the baker may sell his bread "of any weight or size he thinks fit," provided that he sells it by weight, which means that the weight must be declared at the time of sale.

The Shop. We shall now step from the bakehouse into the shop. The best attendant for the baker's shop is a member of the baker's family in the modest venture we have been discussing. Indeed, the whole business of a baker is, more than almost any other, a family affair, and success depends upon each individual doing his or her allotted part well. The baker's wife is the best person behind the baker's counter. There is scope for womanly taste and skill in rendering the shop inviting, and in setting out its contents in an appetising manner.

The Window. The baker has wide choice in window arrangement. There is being exhibited a tendency to refrain from overloading the windows with stock, and it must be remembered that a few articles tastefully arranged are infinitely better than a mass of stuff which remind one of the painful necessity of eating rather than of the pleasures of the table. Our illustration [1] shows a good design in a suspending arrangement, which we select from the specialities of Messrs. F. E. and G. Maund, of London. It is in lacquered brass, relieved with burnished copper, and has two ground and polished plate-glass shelves. The price of an article of this sort is about £6. It may be objected that too much show of metal-work attracts attention to the fittings instead of to the displayed merchandise. Excellent brass and plate-glass suspending arrangements may be had at half this price. Black iron window fittings, though excellent in many places, are not desirable in a confectionery window. Nothing looks better than brass and glass.

Interior Decoration. Money may be judiciously spent upon internal fittings and decorations. White enamel paint is the most appropriate for a baker and confectioner's shop. Our illustration [2] shows an attractive interior. Assuming the shop to be 16 ft. by 20 ft., the cost of fitting up would be about £150 in deal and £175 in American white wood. This includes complete fittings on both walls, two counters, a cash-desk, four air-tight glass cases, marble tops to the counters, and back fittings and full-plate mirrors at back of the shelving. Expense could be modified with details

Show-stands. There is no excuse for the baker and confectioner who neglects to have attractive show-stands about his counters. Makers of such things offer a selection that is embarrassing. Less than a five-pound note will purchase the strong, five-tray stock rack shown in 4. The trays as they come full from the bakehouse may be slipped upon the angle brackets of the rack. To fill up a corner either in the window or on the counter or shelf, the type illustrated in 3 is a favourite. It may be purchased for 30s.

Purchased Merchandise. The baker —especially if he be also a confectioner—does not manufacture all that he sells. He may handle factory biscuits and sweets. The chief value of factory biscuits is that they fill up space, making an appearance in a shop which might, when the trade of the day is over, be very bare indeed without them. They seldom yield a larger profit than 1½d. to 2d. per pound, and there are a good many quarter-pound customers. Sweets and sugar confectionery pay much better—seldom less than 100 per cent. on cost price, and often a good deal more. They are, therefore, worth encouraging.

Horse and Van. The upkeep of a horse and van in a city like London cannot be reckoned at less than 20s. per week. In country places it may be somewhat less, down to 12s. a week in a village. A good van fresh from the works costs £35, but a second-hand one suitable for a new start may be had for half this figure. If cheaper than the latter sum, there is usually something wrong with it, and it often happens that investment in a new vehicle would have proved more economical than the purchase of a second-hand article. Paint, like charity, can be made to cover a multitude of sins. The chief point in buying a second-hand van is to see that the wheels are good. The price of a suitable horse varies considerably; £15 must be paid for one, and more, if possible. The sum mentioned may include a spavin and a few sand-cracks, but one cannot have everything for three five-pound notes. If the baker does not aspire to employ animal traction, £10 to £15 will purchase a good covered baker's barrow or a cycle delivery carrier.

Handbooks. There are many handbooks on baking and confectionery published. We suggest the names of a few that are really meritorious.

"The Bread Acts," by J. F. Rowe, 6d.; "Lectures on Bread-making," by John Kirkland, 2s. 6d.; "Practical Hints on Flour," by W. T. Bates, 1s.; "Hot-plate Goods," by R. Gommez, 9d.; "Slab Cakes," by F. Houghton, 3s. 6d.; "The Art of Confectionery," by George Cox, 10s. 6d.; "Figure Piping and its Uses," by F. Russell, 2s. 6d.; Book of Designs, by Herr Willy, 5s.; "Jago's Science and Art of Breadmaking," 16s.; and "Jago's Principles of Breadmaking," 2s. 6d.

The Bakers' and Confectioners' Exhibition, held each September in the Agricultural Hall, Islington, London, is highly instructive for the practical baker who attends it with his eyes open.

Continued

WHAT WE KNOW OF THE ETHER

Its Mass and Properties. Ether and Matter. Theories Regarding the Cause of Gravitation. Radiation Pressure and its Bearing on Gravitation

Continued from page 900

By Dr. C. W. SALEEBY

WE cannot go far with the study of gravitation before we find it necessary to imagine the existence of an invisible something which is now called the *Ether*. The history of the idea that apparently empty space is filled with an infinitely delicate substance of great importance is very interesting.

What is Light? The first term that was employed was the *luminiferous ether*—that is to say, the light-bearing ether. The older theory of the nature of light—a theory supported even by the great Newton—was that it consists of the propulsion of countless hosts of minute bodies, some of which enter the eye and cause the sensation of light. But that theory had to be abandoned, and there was substituted for it the now universally accepted wave theory of light, which asserts that light is a kind of wave motion—in what? Between us and the sun, for instance, there is apparently nothing at all except a few miles of air. If light be a wave motion, then the space between us and the sun must be filled by an invisible something, in which the motion occurs, and this invisible something was called the luminiferous ether. Its existence, at first merely suspected, is now beyond dispute. We know that it transmits not only the waves of light, but also the waves of radiant heat, the Hertzian waves of wireless telegraphy, the ultra-violet waves which now cure lupus, the Röntgen rays, and many more. So certain is the existence of the ether that modern chemistry is inclined to believe that what we call ordinary matter is none other than a special product of the ether—in other words, that the ether is the mother of matter. Now, what has all this to do with gravitation?

The Mystery of Influence. When we come seriously to think about the fact of gravitation, we find it impossible to understand how one body in space can exercise an influence on another, unless there be some medium between them by which that influence can be transmitted. Now, what can this medium be? Dr. Thomas Young—a distinguished physician to St. George's Hospital, London, founder of the wave theory of light and discoverer of the key to the Egyptian Hieroglyphics—declared that "a luminiferous ether pervades the universe, rare and elastic in a high degree." Surely, if there be such a luminiferous ether, it must be the medium by which the force of gravitation is transmitted. So far this is all very well, but we soon encounter the most serious difficulties.

In the first place, if the ether is to vibrate so as to give rise to light, it must have the property of rigidity, as found in solid bodies, such as a stretched string. But it is very difficult to square our idea of such a rigid body with the motion of matter through it. In fact, we seem compelled to endow the ether with a number of properties which appear to be incompatible with one another. Indeed, two great philosophical students of science, Auguste Comte and John Stuart Mill, entirely disbelieved in the existence of the ether at all, and we can sympathise with them. Nevertheless, it is impossible to agree with them, for the fact of gravitation, if no other, compels us to assert the existence of such a substance. If there be no ether, we must believe in the possibility of action at a distance—that is to say, the possibility of one thing affecting another without the existence of any means of communication between them. So we must do our best, despite difficulties, to ascertain the nature of the ether, being well assured that, once we have solved this problem, and the allied problem of the relation of the ether to the ultimate constituents of matter, we shall have in our hands the key to the problem of gravitation.

The Ether and Matter. Now, we have already seen that weight is a consequence of gravitation, and we are compelled to assert that the ether, by which one portion of ponderable matter exerts gravitation and attraction upon another, is itself without weight. Thus, in contra-distinction to the imponderable ether, we often speak of "ponderable matter." But to assert that it has no weight is by no means to assert that it has no mass; our previous inquiries have already shown us this. In order to do the work which we assert of it the ether must have mass, and here we encounter a source of confusion which is extraordinarily widespread. It actually vitiates a large part of the argument of no less a person than Mr. A. J. Balfour, in his Presidential Address to the British Association, at Cambridge, in 1904. Referring to the modern doctrine that ordinary matter—ponderable or weight-possessing matter—is only a specialised form of ether, Mr. Balfour declared that "matter has been not only explained, but explained away." Like so many others, he has completely failed to realise that all our notions of the ether, without exception, *are derived from our notions of matter*. The differences between the two are no doubt profound, since, for instance, one has weight, whilst the other, without weight, is yet the cause of weight; but, nevertheless, in discussing the ether we are discussing a *material* entity—rarer perhaps a thousand millionfold than the rarest gas, but nevertheless material.

Properties of the Ether. Having cleared our minds of this confusion, we must proceed to ask ourselves what are the properties which we can assert with any decision of this mysterious substance. According to a great student of the subject, Lord Kelvin himself, the ether must be continuous ; there must be no holes, gaps, or cracks in it ; it cannot be atomic in the sense that matter is atomic ; it must consist not of a collection of particles, but of an absolutely continuous substance. A word frequently used to express this property is *homogeneous*. The ether must be homogeneous—continuous and uniform throughout.

A Stone in a Pond. Even in accepting this apparently simple and necessary assertion, we find ourselves met with a difficulty, as Herbert Spencer pointed out. For how are we to conceive of a wave movement in a continuous medium ? Of course, we are familiar with wave movements in mediums which are apparently, but not really, continuous. When you throw a stone into a pond you excite a wave movement in a medium which looks continuous, but, of course, it is not so in reality. You know quite well that certain particles of the water must be moving past certain others, and if this be so, the medium is not really continuous. But indeed how can there be any wave motion in a continuous medium ? The waves of light in the ether must mean—if they mean anything—a state of more or less local motion, and there can be no local motion in a medium which is really continuous. Needless to say, we are not yet in a position to explain this difficulty. If we are honest, however, we have to state it, and the people who always rejoice at the difficulties of science may have their laugh if they will. "The laughter of fools," said Solomon, "is as the crackling of thorns under a pot."

The Light through the Window. Now, the ether is certainly continuous in the sense that ordinary matter offers no interruption to its continuity. It has sometimes been asked what happens to the ether as the earth passes through it in her endless journey round the sun. It has been thought that the earth must push the ether aside, just as she would if she were passing through an ocean of water. This would imply, of course, that the ether is not continuous, since it suggests that from the exact portion of space occupied at any moment by the earth the ether must have previously been expelled. Certainly more in accordance with our modern views as to the ether is the doctrine that the matter of which the earth is composed flies right through the ether without in any way pushing it to one side. It must certainly be the case that the ether can exist in space which is apparently fully occupied by ordinary matter. Take, for instance, the passage of light through your window. A series of ether waves strikes one side of the pane of glass and emerges unchanged at the other side ; the waves brighten up the point of glass through which they pass ; there is certainly absolute continuity of the ether wave—that is, of the ray of light. This can only mean that there is ether present in the glass. It cannot possibly be explained as meaning that the ether wave on reaching the pane of glass is transformed into a glass wave, and that this glass wave, on reaching the inner surface of the pane, is retransformed into an ether wave, which has the same properties as the orginal one.

Lord Kelvin's Theory of the Ether. We speak advisedly when we say that the ether, somehow or other, is continuous. It is continuous not only within itself, but with ponderable matter. Only on the assumption that there is no break of continuity between ether and ordinary matter can we explain the transmission of light through portions of matter, or the fact that one portion of matter acts upon another gravitationally by means of the ether. Indeed, the only possible conception is that the ether is absolutely omnipresent, and that ponderable matter is a specialised manifestation of it. As to the essential relation between ether and ordinary matter various brilliant guesses have been made. Perhaps we must consider matter as consisting merely of points of extra density of the ether. That seems simple, but it is not very satisfactory. Perhaps we must consider that portions of the ether have somehow become cast in the form of vortex rings, like the rings issuing from a smoker's mouth ; this is the famous *vortex theory* of Lord Kelvin.

There are many problems still unsolved, but some things are, at any rate, quite certain. That there is an actual entity corresponding to what we call the ether, there can be absolutely no doubt whatever. Sometimes, when the biologists and the physicists are having a little quarrel, the former assert that the ether is a "convenient fiction," or a "baseless hypothesis," or something of the sort, but the reader may be assured that competent observers have no doubt at all that the ether does actually exist. He must not pay too much attention to what people say when they are angry. The difficulties of describing the properties of the ether in any intelligible manner we must freely and humbly admit. But we are getting nearer to a solution ; we have travelled very far even in the last five years. There is hope for physicists in the great mind of Lord Kelvin, though it is now in its eighty-second year. Even so long ago as 1888 he showed that certain of our difficulties in describing the properties of ether can be met, "provided we either suppose the medium to extend all through boundless space, or give it a fixed containing vessel as a boundary." The celebrated Baltimore lectures delivered by Lord Kelvin in 1884 give us a splendid exposition of the conception that the ether is really a continuous, homogeneous, non-atomic, elastic solid.

Let us now, having studied so far as may be the nature of the ether, return to the question of gravitation, and see whether we are able to express any opinion as to its cause.

The Cause of Gravitation. The study of the cause of gravitation is as difficult as it is important. Only in very recent years do we appear to be reaching the point at which we shall be able to make up our minds on this matter. For instance, the article on gravitation published by Sir Robert Ball in the "Encyclopædia Britannica," in 1880, and included in the last edition of that work, contains no allusion whatever to the cause of gravitation—not even a hint that the question may be raised at all. But there was little chance of understanding the cause of gravitation until we had at least arrived at somewhat truer notions of the nature of matter than those of the year 1880; and we may suppose that it really did not seem worth while to discuss a subject about which nothing whatever was known or seemed likely to be known. Indeed, we may quote the words of a writer, who says: "Since the time of Newton the doctrine of gravitation has been admitted and expounded till it has gradually acquired the character rather of an ultimate fact than of a fact to be explained." (Clerk-Maxwell.)

Flying Bodies in Space? The most celebrated theory of the cause of gravitation is that of Le Sage, of Geneva, published in the year 1818. He considers that the whole of space is filled with minute bodies flying about in all directions. These he supposes to be so small that they very rarely strike one another; they are almost immeasurably smaller, he fancies, than the particles of ponderable matter against which they must very frequently strike.

Now, if there were only one single body in space it would receive on the average about as many blows on one side as on another, and thus would not be urged to move in any particular direction; but if we imagine two bodies in space it is plain that each of them will shield the other from a proportion, however minute, of these tiny projectiles conceived by Le Sage. Thus, the side of each body which is next to the other body will receive fewer blows, and the two bodies will be moved towards one another in virtue of the excess of blows they receive on the sides furthest from one another. Now, supposing that were the actual state of affairs, it would yield a law of gravitation which bears an extraordinary resemblance to the law we know. For instance, the force of attraction would vary inversely as the square of the distance between the two bodies. Further, it would vary directly in proportion to the areas of sections of the two bodies taken through them at right angles to the line between them. Thus, if we can imagine bodies so constituted that these areas—the areas that shield the other bodies from blows—are proportional to the mass of the bodies, we find that the law which would hold if Le Sage's theory were true is absolutely identical with the observed law of gravitation. Thus, the theory of Le Sage is not only a signal instance of the brilliant use of the scientific imagination, but—and this is very much more important—looks as if it might be, in some measure, at any rate, an approximation towards the truth.

Criticisms of the Theory. An obvious objection will present itself. As far as we can possibly detect, gravitation acts between any two bodies with precisely the same force, whether or not there be a third body intervening between them. The attraction exercised by the sun upon the moon is apparently just the same when the moon is eclipsed—that is to say, when the earth intervenes between her and the sun, as at other times. Hence, as Le Sage himself pointed out, it is necessary to suppose that only a very few of the particles which he imagines to be flying about space are stopped by any solid body, most of them passing on through the relatively wide intervals which we must conceive as existing between the ultimate particles of ordinary matter.

Clerk-Maxwell spent considerable thought upon criticism of Le Sage's theory—"the only theory of the cause of gravitation which has been so far developed as to be capable of being attacked and defended." Those words were written more than 30 years ago. This is not the place in which to consider the various more or less recondite criticisms made by the great physicist, but we may just briefly note that one of the chief difficulties suggested—namely, that the energy contained in these rapidly moving particles of Le Sage would necessarily raise to a white heat every material body they encountered, is disposed of if we are able to accept the theory of Lord Kelvin—that the particles are not mere points, but are of the nature of vortex atoms.

Now, the reader may well ask, what has all this about rapidly moving particles flying in all directions through infinite space to do with what we have already asserted, concerning a continuous, non-atomic—*i.e.*, non-particulate—elastic ether? And certainly we admit that there does seem to be very little compatibility between the two conceptions; but it must now be shown that a very recent and very important discovery has led us up to a point at which it seems possible that this promising theory of Le Sage may be re-stated in a form that is entirely compatible with our modern conceptions of the nature of the ether.

The Pressure of Light. The subject of gravitation is so colossal and so fundamental that we are compelled to treat it as a whole, and therefore we offer no apology for taking out of what perhaps may be regarded as its proper place the subject of radiation-pressure—and more especially the pressure of light. Since this subject has lately been shown to have no small bearing, as it appears, upon the essential nature of gravitation, we cannot possibly afford to wait for its discussion until we reach the part of our course which deals with light.

As we have seen, Newton taught that light—or rather the objective basis of light—consists of the propagation of minute particles or corpuscles which travel at immense speed in straight lines. In thus advocating what is called the corpuscular theory of light Newton retarded the progress of optical science for many decades after his death—a conspicuous instance of the malign power of authority. Now, if light consisted of a corpuscular bombardment, it would exercise, however faintly, a pressure not distinct in principle from the pressure of one hand upon another; and it has long been believed that light does exercise such a pressure, but the experimental evidence of this belief has not been forthcoming. In one respect, this is fortunate; for if it had been possible to quote experimental proof that light exercises a pressure, the fact would certainly have been regarded as strongly in favour of the (false) corpuscular theory of light as against the (true) wave motion theory.

But when Clerk-Maxwell associated light with other forms of radiation in the ether, such as radiant heat and electricity, and established what is now called the electromagnetic theory of light—now universally accepted—he showed that even on this theory, just as much as on the discarded one, light must exercise a pressure. For convenience of reading we use the word light, but it must be remembered that this pressure is common to light and all other forms of ethereal wave motion of the same kind. It makes no difference to its pressure whether or not a particular rate of motion happens to have a special action upon the human eye. Clerk-Maxwell actually proceeded, by use of various abstract mathematical considerations, to frame a formula which would express, he declared, the measure of the pressure of light—a pressure which had not then been demonstrated.

The Radiometer. It is now many years ago since Sir William Crookes followed those who had attempted to demonstrate what we shall henceforth know as radiation-pressure. His *radiometer* is familiar to all—a series of delicately balanced vanes, bright on one side, blackened on the other, which lie in a partial vacuum in a glass bulb. Exposure to sunlight or even the end of a lighted cigar causes these vanes to revolve. But it was shown that this effect is not due to light-pressure, but to the unequal heating, and consequently unequal atomic movement, of the remaining air in the bulb, due to the varying absorptions of the bright and blackened surfaces of the vanes.

Some four years ago, however, radiation-pressure was positively demonstrated, independently, by the great Russian physicist Lebedew, and by two American observers, one of whom—Professor E. F. Nichols—excited much interest amongst the physicists in this country by lecturing and showing his original apparatus at the Royal Institution, in May, 1905. Lebedew's method was based on the advice of Maxwell, which was simply to obtain as high a vacuum as possible, so as to exclude the action of heated gases, as in the radiometer, and thus to detect any action due to the pressure of light alone.

Radiation-Pressure. Professor Nichols and his co-worker proceeded on different lines. They employed no vacuum, but were nevertheless able to exclude the gaseous action, which takes some time to manifest itself, whereas the effects of light-pressure are naturally instantaneous. It is impossible to describe on paper the details of the method which the discoverer found complicated apparatus necessary to explain. Let us merely observe that the fact of radiation-pressure has now been established, that its amount has been measured, and that the measurements coincide within extraordinarily narrow limits with the results reached by Clerk-Maxwell, working from purely mathematical assumptions. Given that radiation-pressure is a fact (and a universal fact, be it remembered), the question now is as to the general significance of this most important discovery.

Of course it explains that for which an explanation has long been hoped, the development of tails by comets when approaching the sun. It explains not only the formation of these tails, but their increasing width as they pass away from the nucleus of the comet, the cases in which there are several tails—as in the celebrated comet of Donati—and the manner in which they push their trains in front of them as they leave the royal presence; but this does not represent anything but a tiny fraction of the cosmic significance of radiation-pressure.

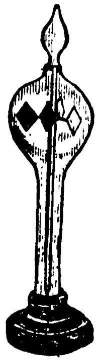
A Universal Force Opposed to Gravitation. It is as we have already hinted, a mere accident, so to speak, of our constitution, that we can see certain forms of radiation, can feel others, and can perceive yet others not at all. We have seen that the Hertzian waves, the infra-red waves (that is to say, the waves that lie just below the red rays in ordinary sunlight), the rays of light, the ultra-violet rays, and many more, are related to one another, just as one musical note is to its neighbours.

Wherever, then, there is a luminous body, wherever there is a body which is possessed of any heat whatever, wherever there is a body which is a source of electric energy, there is a source of radiation-pressure. It amounts to this then, that we now have positive evidence of a universal force which is comparable to gravitation, but acts precisely in the opposite direction. As gravitation attracts, radiation-pressure repels.

In the case of large bodies, as the sun and the earth, radiation-pressure does not amount to one billionth part of gravitation, but in the case of the particles in a comet's tail we see that, despite the enormous mass of the sun, radiation-pressure far outdoes gravitation. In other conditions the two forces will balance one another. Now, every body that is above the absolute zero of temperature exerts this force—and at all distances—its power decreasing with distance in the same ratio as does the power of gravitation. The unqualified assertion of Newton, then, that all bodies whatever attract one another with a force which is proportionate to their mass and varies inversely as the square of the distance, is found to be only ideally true; for most, if not all, bodies also repel one another in accordance with an equally precise law. It is possible to combine the two into an algebraic expression, without reference to which the law of gravitation should now no longer be stated.

"One Universal Heap of Matter." Let us now briefly consider some of the consequences of radiation-pressure—of the fact that there is a mutual repulsion as well as a mutual attraction between bodies. In the first place, we must reconsider the view which has often been maintained that all matter in the universe will ultimately be agglomerated into one dense heap in virtue of gravitation. Again, we find that we now have another factor besides the action of the tides, pointed out by Sir George Darwin, to consider as interfering with the stability of the Solar System. But furthermore, we observe, as has been already shown, that the first law of motion can no longer be held as unqualifiedly true, even if the motion be through an untenanted and perfectly frictionless ether. It is said that, in such conditions, a body in motion must so move, in a straight line, and at the same velocity eternally, if no force be impressed upon it. That, doubtless, is really true, but when are the conditions realised? For any body that emits radiant-energy—*e.g.*, any body such as the sun or the earth—contains within itself a cause of retardation. On its onward path it leaves waves of radiation behind it and sends them in front of it. But in so doing it tends, as Professor Poynting has shown, to "crowd upon" the waves in front, whilst those behind it are "thinned out." In other words, the radiation-pressure will be greater in front than behind, and therefore the speed of the body—and this applies alike to a Sirius or a bullet—will constantly be diminished.

Its Bearing on Gravitation. In considering the future of the Solar System, then, we have to recognise, in planetary radiation, and in the effects of the solar radiation, causes which tend to retard that motion in virtue of which alone the planets are prevented from falling into the sun. But it appears evident that such a catastrophe, even were it to occur in such a fashion as not to induce the evolution of much heat, would by no means introduce a final state of "death" of the Solar System, as used to be thought.


RADIOMETER

And now for the bearing of all this on gravitation. Here is a universal force which acts in a direction precisely opposite to that of gravitation, and which is in certain conditions more powerful than, in other conditions as powerful as, and in yet others less powerful than, the more familiar force.

It is plain, then, that, as we have already said, it will not do for any future writer to discuss gravitation without reference to the fact of radiation-pressure. But does this new discovery help to give us any clue to the cause of gravitation? That would be a surprising contribution from a source which interferes with the action of gravitation. But it appears to be conceivable. We recall the theory of Le Sage, which we have just discussed at what might have seemed, a year or two ago, disproportionate length. Suppose, for instance, that for the pressure due to the minute particles pictured by Le Sage—particles of which we have seen that subsequent science knows nothing at all—we substitute the pressure of radiation, might we not then be able to find a germ of truth in Le Sage's theory—indeed much more than a germ—even though that theory requires considerable modification in its statement?

The subject is yet too new for dogmatism, but we note that no less an authority than Sir George Darwin lately read before the Royal Society a paper dealing with the possibility to which we have referred, the possibility of harmonising Le Sage's theory of the cause of gravitation with the fact unsuspected by him, the fact of radiation-pressure.

What we Cannot Understand. It would certainly be too much to say that we shall ever have to look upon gravitation as merely the negative aspect of radiation-pressure, just as Le Sage imagined gravitation to be merely the negative aspect of the repulsive pressure of his imaginary particles; but it will be strange indeed if there does not turn out to be a most intimate relation between these two universal facts. This, then, is all that we can as yet possibly say concerning the cause of gravitation. It is vague and tentative enough, the reader may say, but nevertheless it opens out new possibilities of knowledge and comprehension which were quite unsuspected by the nineteenth century.

Finally, let us note how close we are to the inconceivable. You could push one of Professor Nichols' recording vanes with a pin, or by a puff of the breath. In each case some material is moving against the vane. Similarly, you can push or "strike" the vane with a beam of light. But in this case—though light-waves travel at a known speed—nothing material, even if we include the ether as material, moves onwards, as does the pin or the puff of air. Try to conceive how a thing may be struck and moved by that which has no material existence. Failing this, try to form a "clear and distinct idea" of the *that* in question! Only the most foolish kinds of materialists, left high and dry from thirty years ago, think that they or anyone else can really understand the inner nature of Energy

Continued

AND ROOT CROPS

Varieties of Clover. Twofold Value of the Plant. Root Crops Described: Mangel, Beet, Turnip, Kohl-rabi, Carrot, Parsnip and Potato

By Professor JAMES LONG

CLOVERS

This useful plant (Nat. ord., *Leguminosæ*) belongs to the genus *Trifolium*. The principal varieties are of great value for feeding sheep on the ground, and thus improving both stock and soil—for hay, and occasionally as green forage. They are handsome, with somewhat round-headed blossoms and compound leaves, each leaf being provided with leaflets, while the seeds are produced in pods, or legumes. The chief varieties grow admirably upon the medium and heavier soils, and are sown both for temporary and permanent pastures, while the majority are found in good meadows. The cost of the seed together with its weight is given in the table below.

COMMON YELLOW CLOVER, OR TREFOIL

Broad Red Clover. This variety (*T. pratense*) bears a round, purplish blossom, with leaflets upon which are imprinted a mark resembling a horseshoe.

The colours of the heads of each variety of clover, together with the tiny flowers themselves, the seed-pods and the seed, should be examined by the student that he may be practically acquainted with each. Red clover is cut or fed twice in the year after it is sown, or it may be cut once and subsequently fed or mown for seed. This variety will stand two years, and sometimes more, but it cannot be depended upon. It is seldom grown more than once in eight years on the same field owing to its liability to what is known as "clover sickness." When sown alone, from 14 to 20 lb. of seed are used per acre. When converted into hay, the crop should yield 3 tons in the two cuts, sometimes more. Clover is a most important crop in the ordinary farm rotation, but it is liable to attacks of a parasitic weed known as dodder (see illustration), the seed of which may find its way into clover seed sample.

Perennial Red Clover or Cow Grass. This variety (*T. pratense perenne*), which carries a slightly darker purplish blossom of somewhat smaller size, is closely akin to broad red clover; it stands longer, but only supplies one crop for cutting. The mark on its leaflet is more angular than that of the broad red, which, as indicated, is more rounded in form.

White Clover. White clover (*T. repens*) is common to most of the heavier classes of soil, and though its presence is not apparent, it soon covers a field with rich herbage in response to a good dressing of dung or phosphate of lime, for which reason phosphatic manure is of great value on pastures as well as on meadows.

Alsike. A perennial with a white blossom tinged with pink. It is a strong, vigorous grower, extremely useful in clover and grass mixtures, whether for temporary or permanent leys, and is especially adapted to the heavier classes of soil. It is occasionally used instead of red clover, where, owing to fear of disease, it is not

English Name.	Botanical Name.	Percentage of germination.	Weight per bushel.	No. of seeds in lb.	No. of germinating seeds in lb.	Cost of 1,000,000 germinating seeds.
			lb.			
Broad red clover	Trifolium pratense	98	66	232,000	227,360	3 7
Cow grass, or perennial red clover	Trifolium pratense perenne	98	66	218,000	213,640	5 4
White Dutch clover	Trifolium repens	98	68	782,000	717,360	1 8
Alsike, or hybrid clover	Trifolium hybridum ..	98	66	718,000	703,640	1 3
Crimson clover	Trifolium incarnatum ..	98	66	118,000	115,640	2 10
Trefoil, or yellow clover	Medicago lupulina	98	68	319,000	312,620	1 2
Hop trefoil	Trifolium procumbens ..	96	66	—	—	—
Birdsfoot trefoil	Lotus corniculatus	98	65	412,000	403,760	2 9
Greater trefoil	Lotus major	90	64	360,000	—	—
Lucerne	Medicago sativa	98	65	224,000	219,520	4 0
Kidney vetch	Anthyllis vulneraria ..	98	64	193,000	189,140	4 2

deemed advisable to sow the latter. 14 lb. of seed are used per acre when it is grown alone. Crimson clover is described in the chapter on forage crops.

Trefoil. This belongs, as the foregoing table shows, to the genus *Medicago*. Known also as yellow, or hop, clover, it grows upon various soils, and is specially adapted to those which are poor or dry. Trefoil, which is sometimes known to farmers as black medick, has a hairy stem and leaves, and produces seed of a brownish yellow, which is frequently used in mixtures, especially on down lands, many of which are chalky in character. The seed sown for a pure trefoil crop is 15 lb. to the acre.

Hop trefoil, which flourishes on limestone pastures, can scarcely be described as a cultivated plant. Birdsfoot trefoil, although a valuable plant, is practically wild, and is commonly found in poor or dry soils of various classes. Its flowers, first almost crimson, change to brilliant yellow, while the peculiar form of the seed-pods has given rise to the common term birdsfoot. The Greater Birdsfoot Trefoil does not adapt itself so well to dry soils or soils which are of an extremely poor character.

Zigzag Trefoil is useful in pastures, but, like hop trefoil, is seldom found in seedsmen's or farmers' mixtures. The Kidney Vetch, again, is seldom sown unless under special conditions. It is common to pastures of various classes, especially those of a sandy character. The student will not fail to recognise it owing to the peculiar form of its yellow flowers, commonly known as "ladies' fingers."

ALSIKE CLOVER

RED OR BROAD CLOVER

PERENNIAL WHITE CLOVER

Twofold Value of Clovers. The student of agriculture can scarcely devote his attention to any family of plants which is of greater importance than the clovers. Their value is twofold; they produce a very large quantity of forage of the highest feeding value for stock of all classes—we include swine and poultry—and they materially add to the fertility of the soil, even though the crops be entirely removed from the surface. The clovers, like peas, beans, vetches, lucerne, and sainfoin—all of the same natural order, *Leguminosæ* —are known as nitrogen gatherers. How they appropriate the nitrogen of the atmosphere is described in the chapter on soils. It is possible to grow much larger crops than the average British yield by greater liberality in the employment of phosphatic manure and of potash, where this mineral is needed. We may further add that if by such a form of manuring the weight of a crop is increased, the richness of the soil will also be increased, and a more than usually successful succeeding crop practically ensured.

When well fed with the mineral fertiliser the clovers are enabled to appropriate more nitrogen, and thus to produce more herbage. At the same time, the soil is enriched owing to the additional nitrogen in the roots and the unexhausted phosphates and potash.

ROOT CROPS

The Mangel. The mangel (Nat. Ord., *Chenopodiaceæ* [*Beta vulgaris*] is a biennial, deep tap-rooted plant, which thrives on the stiffer soils, especially loams, in most parts of England, the north excepted. There are many commercial varieties, which are divided into the Long Reds, and the Globe and Tankard, or intermediate shaped yellows. The mangel is grown to large size, and we have measured bulbs 37 in. in circumference, six of which scaled 131 lb. It needs rich soil or ample manuring, especially responding to dung, nitrate of soda, and salt. Where the dung used is small in quantity, these artificials may be supplemented by super-phosphate on soil, rich in lime, or, where this is deficient, basic slag. The seeds grow in capsules, each of which contains from three to five. They are sown at the rate of 7 lb. to the acre by the drill, or, if dibbled by hand, much less will suffice, but by this method they are more liable to be taken by field mice. A bushel of seed weighs about 21 lb., each lb. containing over 20,000 seeds. Where the crop is grown from seed, it should reach 50 bushels to the acre. The mangel crop may reach any figure, from 10 to 80 tons per acre, with 3 to 5 tons of tops, but 30 tons may be regarded as quite satisfactory. It is rich in sugar, of which it contains approximately 8 per cent., but the proportion varies largely in accordance with the variety.

TANKARD SWEDE

KOHL-RABI

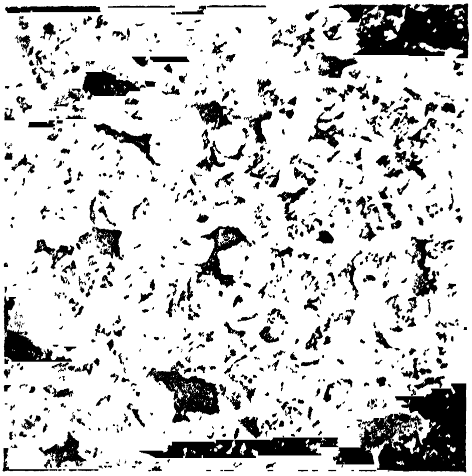
The Beet. The beet is a modification of the mangel, having been improved by selection; may contain over 14 per cent. of sugar, the production of which is influenced by abundant sunshine. The weight of a mangel crop is not an actual indication of its feeding value, for a much smaller crop of one variety may contain a greater weight of feeding matter per acre than a much larger crop of another variety grown on the same soil under the same system of cultivation. The mangel is a suitable food for all classes of farm stock. It is preserved by clamping, or pitting, and is more suitable for consumption after the completion of the year, and is often in use to the following July. It contains more dry matter than either swedes (12½ to 11) or white turnips (12½ to 8).

Turnips. The turnip (Nat. ord., *Cruciferæ*) embraces the swede (*Brassica campestris*), known as Rutabaga on the Continent, and the common turnip (*Brassica campestris Raba*), both the yellow and white fleshed. It is a biennial, and one of the most valued of English plants, especially for sheep feeding on light land, which it enables the farmer to cultivate with success. The swede is hardier and richer than the turnip, from which it differs in two points, with the exception of one or two commercial varieties; it has a neck, which the turnip has not, whereas its leaves are bluer and smoother than those of the turnip. Both swedes and turnips vary in colour; in some the top portion of the bulb is purple, and in others green. Turnips and hybrids are grown in succession as sheep and stock foods, being usually consumed before the swede, owing to the fact that they will not stand severe weather. The swede, however, frequently passes unscathed through the winter, but it is always a wise precaution to lift and clamp or pit it for safety.

TANKARD TURNIP

Turnips of all kinds respond liberally to dung and phosphatic manure. The seed is sown by the drill, which deposits the chemical manure, where this is employed, at the same time, 3 to 4 lb. of seed being drilled per acre, and from 3 to 5 cwt. of phosphates. Sowing varies with the climate and the soil, but May and June are the chief months. The seed weighs 50 lb. to the bushel, there being 23 to the grain, and, therefore, about 160,000 to the lb. The bulbs weigh some 42 lb. to the bushel, but individual swedes may reach 20 lb. each. In measuring

FARMYARD SCENE: BRINGING THE MANGELS HOME



MANGEL SEED

a prize sample we found that some reached 37 in. in circumference, while the lot of six scaled 120 lb. Turnips, however, may reach almost the same weight. When the roots are singled to 18 in. apart, there are 19,360 to the acre; when 27 by 9 in., there are 26,000.

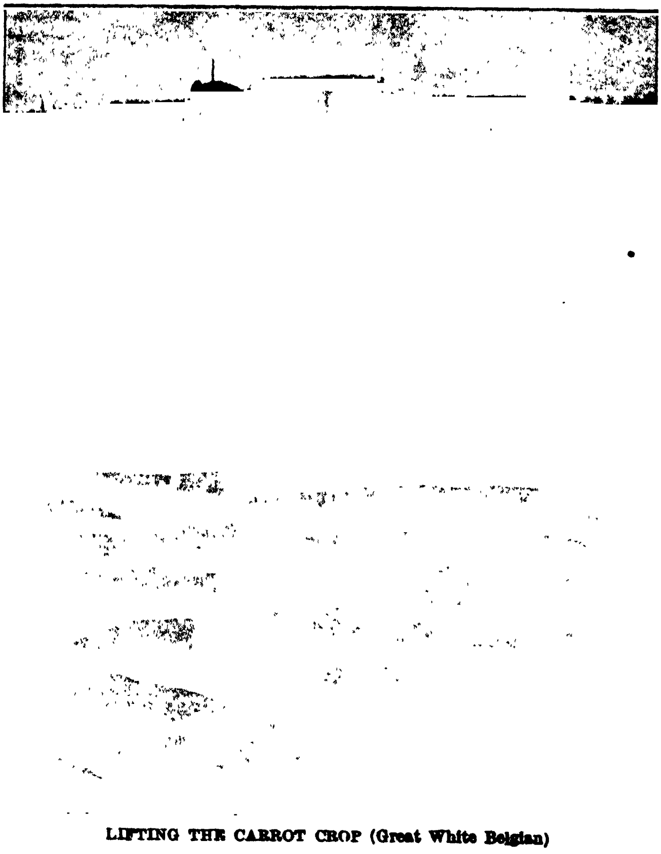
It was shown by Voelcker that turnips grown 10 to 11 in. apart were much richer in sugar than those grown 20 in. apart, hence the practice of growing swedes and turnips, beet and mangel, of medium size, and consequently closer together. When grown for seed, an acre of swedes yields about 28 bushels, and of turnips 20 to 24 bushels. A swede crop grown on good land under good cultivation should average 20 tons, and white and yellow turnips 22 tons to the acre. The British average for swedes and turnips covering ten years is, however, only 12¾ tons, as against 18¼ tons of mangels. The tops, or leaves, of the turnip crops are much heavier than those of the mangel, varying from 15 to 20 per cent. Unfortunately, the tops of swedes, like the tops of mangels, cannot be preserved; but ploughed into the ground they form a useful green manure. According to Voelcker and Warington the following are the manurial constituents removed in root crops.

Crops.	Weight.	Phosphoric Acid.	Potash.	Nitrogen.
	Tons.	lb.	lb.	lb.
Turnips with leaves ..	17	33	148	120
Swedes, do...	14	21	79	102
Mangels, do.	22	49	262	147
Potatoes with haulm ..	6	26	76	67

The depth at which seed is sown is especially important in the case of seeds so small as that of the turnip, which closely resemble that of the noxious weed charlock, belonging to the same family. The following table indicates the relation between growth and the depth of the soil.

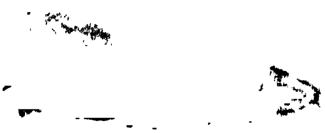
	Inches in depth.	From 40 seeds plants came up.	Proportion per cent.
Swedes :	1	31	77
	2	29	72
	3	20	50
	4	10	25

Kohl - rabi. Of this cruciferous plant (*Brassica oleracea caulorapa*), which may be described as a turnip-rooted cabbage, there are two varieties, the green and the purple. It suits heavy soils, on which cabbage thrives the best



LIFTING THE CARROT CROP (Great White Belgian)

Rabi is one of the most healthy foods on the farm; hardier than the turnip, and suitable for consumption at any time, it deserves to be more extensively grown. It possesses one advantage not common to the turnip, it transplants well, and thus, if grown in a seed-bed, it enables the cultivator to devote a longer time for the preparation of the soil into which it is to be removed. Unlike the turnip, it is seldom attacked by disease. If drilled in the field, from 2 to 4 lb. of seed are required per acre, but if sown in a seed-bed 3 to 4 lb. of seed will suffice for a rod of land. The weight of the seed reaches nearly 56 lb. to the bushel, the number of seeds in a lb. reaching about 125,000, while the crop produced per acre should reach 20 tons.



KIDNEY POTATO, SUTTON'S IDEAL

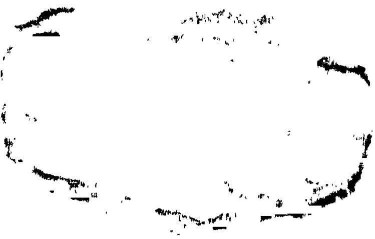
Field Carrots. The field carrot (*D. carota*; Nat. ord., *Umbelliferæ*; genus *Daucus*) is a biennial, growing best in a deep, fine, light soil, excluding those of the lightest character, while not thriving in the heavier soils. Although costly to grow, the carrot is one of the best known foods for cows. Under good cultivation it is grown to enormous size, and provides a crop of from 14 to 18 tons per acre, or even more. The seed sown (10 lb. to the acre), mixed for convenience with sand or fine ashes, weighs, in its natural condition, 15 to 18 lb. to the bushel, a lb. containing about a quarter of a million seeds. The leaves, although small, form an excellent addition to a ration

ROUND POTATO. SUTTON'S WINDSOR CASTLE

The Parsnip. The parsnip (genus, *Pastinaca*), of which one species is grown (*P. sativa*), is a hardy biennial, growing most freely in the lighter soils, especially if rich and deep. Like the carrot, it is an excellent and sweet food for cows, and is easily kept through the winter either clamped or in the ground. A good crop exceeds 12 tons to the acre. The seed, 6 to 7 lb. per acre, is drilled, and is better mixed with sand or very fine soil; its weight is 15 to 18 lb. per bushel, and there are about 100,000 seeds to the lb.

Potatoes. There is only one species of the potato grown in agriculture (*S. tuberosum*; Nat. ord., *Solanaceæ*; genus, *Solanum*), but there are many varieties, old ones being abandoned when they fail, and new ones produced. The potato is grown in two forms, the kidney, or fluke, and the round, and with skins of different colours, white, pink, and dark purple. It prefers a light loam, and best of all a rich sandy loam, but it is grown with more or less success in most soils except heavy clay. In Ireland it is largely grown in peat soils, in beds known as "lazy beds," with turnips between. In England it is usually planted in trenches, which are formed by the ridging plough. The soil must be fine, deep, and in good condition. Potatoes are now being grown on an increasing scale under glass for early consumption, and in the fields from tubers which have been encouraged to sprout before setting, the practice resulting in an earlier crop.

The potato is really a tuber, or underground stem, like the artichoke, and is extremely rich in starch, the real fruit of the plant being the berry, which resembles the tomato in this respect. Seed potatoes, or tubers, are known as sets. These are not the real seed, and consequently new varieties cannot be produced from them. A set should contain at least two eyes or leaf buds. It should be of good shape and size, dry and round. Large sets are frequently cut, and in this case it is preferable to use the rose, or large end. In the reproduction of costly varieties, tubers are frequently cut into a number of sets, each containing one or two eyes; the quantity of tubers, sets, or seed, planted per acre, ranges from 25 to 30 bushels, according to their size, a piled bushel weighing 56 lb.



PEBBLE POTATO, SUTTON'S DISCOVERY

The English crop, which is the largest in the world, averages about 6 tons to the acre, the British average being 5¾ tons; but under high cultivation 15 tons, and even more, have been grown. The potato is manured with dung and artificials; in soils liable to drought it is preferable to employ half a dressing of dung, 10 to 12 tons per acre, with a complete artificial manure combining nitrogen, phosphoric acid, and potash, the two latter being deposited in the drills at seeding time. The yield of the potato crop depends upon the vigour and suitability of the variety planted, the manure employed, and the thoroughness of the cultivation.

Continued

OUTLINES OF EDUCATIONAL TOURS ABROAD

Itineraries which will enable Travellers to witness the leading sights of Switzerland and Italy without waste of time

By J. A. HAMMERTON and WILLIAM DURBAN, B.A.

SWITZERLAND

No other country deserves so well the epithet of "the playground of Europe." The Swiss have not only a national genius for inn-keeping—so that their hotels are the best in the world, taken all round—but they know that their marvellous little land is an epitome of all the most magnificent types of scenery. And they have made their "Tourist Industry" quite a special vocation, laying themselves out in all directions to provide for the interests of visitors. Nowhere on the surface of the globe are the most attractive scenic phenomena of mountain, lake, valley, torrent, and glacier presented to the eye in so compact and accessible an area; while the attractions of the cities and villages, and of the simple and unsophisticated people, are, in themselves, inexhaustible.

Very much may be seen on each single day of a visit to Switzerland by means of the short excursions to various lovely spots, all within easy reach of this or that centre. Suppose that the visitor to Switzerland for the first time can spare only a week or ten days. He would be wise to attempt nothing more than a tour through the Bernese Oberland. Even in that brief time he could enjoy delightful glimpses of the glorious scenery to which Berne is the gateway, stopping a day each at such places as Thun, Interlaken, Kandersteg, and Meiringen. But though he could not do much more, he would know for the rest of his life what the sublime aspect of one Alpine range means. He would probably resolve on renewing and extending his acquaintance with those scenes of enchantment.

A Fortnight in Switzerland. If carefully planned, this will bring within the view [illegible] He must, of course, not linger long in any one centre, but the distances are so easy that travel is much more facilitated than in most other [illegible] It is quite possible within a full fortnight [illegible] certain portions both of the Bernese Oberland and also of the southern section of the country, where the Valaisian Alps rear their stupendous summits.

FIRST DAY. From London to Geneva.

SECOND DAY. The richest and largest of Swiss cities is GENEVA. It is the city of the Reformation. The day will be spent in surveying the memorials of that wonderful era. The *Cathedral*, with the beautiful Chapelle des Macchabées, contains black marble monuments and sarcophagi of Dukes Henri de Rohan and Tancred, and of Margaret de Sully. Calvin's chair is under the pulpit. The handsome quays and fine shops, the superb view of the Mont Blanc range, and the lovely lake prospects combine to render Geneva a place of peculiar charms.

THIRD DAY. This should be devoted to excursions from Geneva by the lake steamers. Amongst these the favourite trips are to *Eaux Vives*, *Vesenaz*, *Coppet*, *Nyon*, *Montreux*, and *Chillon*. The visitor has an ample choice for a delightful day.

FOURTH DAY. From Geneva, *via* Le Fayet, by electric railway to CHAMONIX. Excursion to the *Mer de Glace*. This needs no guide. The scene is marvellous, for the visitor is in the midst of the grand Alps of Valais and is by the side of a marvellous glacier. *Mont Blanc* towers above all.

FIFTH DAY. The excursions in the Valley of CHAMONIX are of incomparable beauty. But the tourist will, of course, choose that to the *Pavillon de la Pierre Pointue*, overlooking the *Glacier des Boissons*. Or he may make the easy ascent of *La Flégère* and here also enjoy a wonderful prospect.

SIXTH DAY. From Chamonix to MARTIGNY by the *Tête Noir*. This journey over a grand, wild pass, will make a memorable day.

SEVENTH DAY. By train to Visp and ZERMATT. At the latter place the visitor finds himself in perhaps the most supremely attractive spot in all Switzerland. Before him rises the *Matterhorn* in all its glory, with the *Breithorn* and the *Glaciers of St. Théodule* in full view from the platform of the Zermatt station. Here is the very "sanctuary of the Spirit of the Alps." In the churchyard and also beside the *English Church* are the graves of several victims of the Matterhorn disaster.

EIGHTH DAY. Excursion from Zermatt to the *Gorner Grat* and *Riffelberg*. Here are the grandest views in Switzerland. The mountain panorama is incomparable.

NINTH DAY. The tourist now leaves the Valaisian Alps, and is about to enter the Bernese Oberland for the second section of his trip. LAUSANNE is a very pleasant city interlude between the mountain experiences. A day here is delightful. The nave of the *Cathedral* is magnificent, and the many monuments in it are very fine. The town, on its terraces, commands splendid views of the Alps of Savoy, especially of Mont Blanc.

TENTH DAY. THUN and INTERLAKEN. The tourist can choose how he will divide his time at these two charming spots. He will enjoy that view of the peerless *Jungfrau* which can never be forgotten, and he can take little trips on either of the lovely lakes, *Thun* and *Brienz*. He should not fail to go along the latter, landing to see the famous *Giessbach Falls*.

ELEVENTH DAY. At MEIRINGEN, the grandest gorge in Europe invites a stay. In the *Aar Schlucht* are those tremendous *Falls of the Reichenbach* written about so romantically by Sir Conan Doyle in connection with the "Adventures of Sherlock Holmes."

TWELFTH DAY. At LUCERNE the tourist rests by one of the loveliest of lakes. He will see the famous wooden covered bridge over the Limmat, and will admire the beautifully situated town. Part of the first day should be occupied by a trip up the *Sonnenberg*, where refreshments may be enjoyed while the enchanting prospect is surveyed.

THIRTEENTH DAY. BASLE will repay a stay of a day at the conclusion of the tour. The *Rhine* is here a noble stream. In the *Cathedral* are to be seen the wonderful old frescoes of the *Death Dance*, as well as collections of mediæval curiosities.

FOURTEENTH DAY. The return journey to England.

Longer Tours. *Three weeks* would enable the tourist to stay longer at Lucerne in order to ascend the Rigi and Pilatus, each being scaled by a cog-railway. He could also devote two days to Berne and then give a day each to Zurich and Neuchatel. A *month* would add the additional delight of a stay at Grindelwald, where he would make acquaintance with the Jungfrau at close quarters, with the Wetterhorn, Eiger, and Mönch. He would go to Mürren and to the Lauterbrunnen Valley, and might even visit the Rhone Valley, going up the Grimsel Pass over to Meiringen.

Expenses. The expense of travelling in Switzerland is not great. Indeed, many who must study economy, and must be content with a few days, manage to spend a delightful week in the country at a cost of five guineas. But it is safe to reckon that a comfortable tour in Switzerland runs the tourist to the expense of about a guinea a day. Fares from London to Geneva are: First class, single, £4 16s. 1d.; return, £7 12s. 9d. Second class, single, £3 7s. 2d.; return, £5 9s. 10d. But for a mapped-out plan the tourist should adopt the rundreise system, as this circular ticket enables him within the country to effect a considerable reduction in the fare. The particulars are always easily obtained at any of the agency offices. But, of course, a special route must be decided upon.

The cost of living in Switzerland is very moderate. The managers of the hotels have learned to cater specially for Anglo-Saxon travellers. The charges vary greatly, but the average expense for a day and night, inclusive of everything, may be reckoned at 8 francs a day. Food everywhere is excellent. At the chalets during long Alpine walks milk may be obtained, but it is often the only thing available, so the tourist should take a small supply of food from his hotel for the day. To stay in the towns and to miss such walks is to fail to see the real Switzerland, therefore the tourist should traverse one or two of the glorious passes, such as those already named.

Books to Read. Canon Bonney's "Alpine Regions of Switzerland," Lord Avebury's "Scenery of Switzerland," J. A. Symond's "Swiss Highlands," Dr. C. Manning's "Swiss Pictures," Stephen's "Playground of Europe."

ITALY

Wherever else a traveller may have journeyed, he cannot feel that he has rounded off his experiences as a tourist until he has seen Italy, the land which is the fairest "favourite of the sun," the supreme delight of poets and artists, the marvel of history, and the garden of Europe.

Many of the noblest Alpine summits crown its scenery above the enchanting lakes of the north. All its immense coast-line is fascinating. And the long ranges of the Apennines—with old cities of Etruscan, Roman, and mediæval origin, in which incomparable treasures of art are enshrined perched on their crags—hide in their recesses and valleys countless exquisite beauty-spots. In this glorious peninsula the tourist finds the very acme of the delights of travel. A tour in this land ministers equally to health, to recreation, and to education.

Italy is a vast world in itself. No other land teems with so many centres of attraction. The immense length of the peninsula renders it impossible for the tourist in a brief trip to visit each section of the country. North Italy, Central Italy, South Italy, and Sicily need attention on separate tours. But the two first divisions may be seen and enjoyed in a cursory manner on a single tour, and the same remark applies to the last two. The best beginning, supposing that the traveller wishes to take a fortnight in some of the choicest portions of the country, may be easily indicated.

A Fortnight in Italy. If possible, this length of holiday should be arranged clear of the time needed for reaching the borders and for the homeward journey. We will map out the very best programme for a first tour of this length.

First Day. The tourist should proceed direct to Como by way of the St. Gothard Railway and Lugano. The ancient marble *Cathedral*, with the magnificent picture of the Adoration of the Magi, by Luini, is alone worth the whole journey. Take one of the enchanting trips on the lake, preferably that to *Bellagio*.

Second Day. Going on to Milan, visit early in the morning the incomparable *Cathedral*, one of the wonders of the world, with its 98 Gothic turrets and the 2,000 marble statues on the mighty roof. From this roof enjoy the wonderful Alpine view of Monte Rosa, Mont Blanc, and the Matterhorn. The *Picture Gallery* in the Brera Palazzo. The gem of the collection is Raphael's "Sposalizio." The *Church of San Lorenzo*, the most ancient in Milan, belongs to the fourth century.

Third Day. This also would be spent at Milan. The *Galleria Vittorio Emmanuele*, the largest bazaar in Europe. The *Piazza della Scala*, with the marble monument of Leonardo da Vinci. The magnificent triumphal arch built by Napoleon, called the *Arco del Sempione*. Excursion to the old monastery of *Santa Maria delle Grazie*, containing the famous picture of the 'Last Supper,' by Leonardo da Vinci.

Fourth Day. Arrive at Genoa. The *Palazzo Rosso*, with famous picture gallery, containing many masterpieces of Titian, Van Dyck, Luini, Veronese, Rubens, etc. The *Palazzo Bianco*, with smaller but excellent picture gallery. The *Palazzo Durazzo*, noted for its picture gallery with many works of the great painters of the seventeenth century. The *Statue of Columbus*, near the Harbour. The *Campo Santo*, celebrated for its beautiful monuments.

Fifth Day. Next in order would come Spezia, the Portsmouth of Italy, superbly situated. Royal dockyard. Lovely excursion along the bay to *Porto Venere*. Ruins of ancient *Church of S. Pietro* on site of a temple of Venus. Or, if preferred, take the equally delightful steamer trip by other side of the magnificent bay to *Lerici*.

Sixth Day. This would bring the tourist to Pisa, one of Italy's most attractive cities. The *Campo Santo*, with exquisite monuments and quaint frescoes extolled by Ruskin. The wonderful white and black marble *Cathedral*, *Leaning Tower*, and *Baptistery*.

Seventh Day. Two days at least would have to be devoted to Florence. The *Cathedral*, with glorious façade of coloured marble. The famous *Baptistery*, with the bronze doors called the Gates of Paradise. Giotto's *Marble Tower*. The *Uffizi Palace*, with picture gallery containing many gems of art, including Titian's "Venus of Urbino," Raphael's "St. John," Durer's "Adoration of the Magi," etc.

EIGHTH DAY. On the second day in Florence visit the *Lung' Arno*, and walk in the *Cascine Gardens*. The Churches of *Santa Maria Novella* and *San Marco*. The *Monastery* of San Marco, with the famous paintings in the cells, by Fra Angelico, and the memorials of Savonarola. The *Pitti Palace*, with the world-famous picture gallery, containing superlative gems by the greatest masters.

NINTH DAY. One would now come to SIENA. The black and white marble *Cathedral*, full of famous mediæval wonders. The pavement pictures on marble are the most famous of the kind in existence. The façade is of indescribable beauty. Siena is the most beautiful of all the "hill cities" of Italy. The *Church of San Domenico*, with the lovely chapel of St. Catherine. The *House of St. Catherine*. The *Palazzo Communale*.

TENTH DAY. Spend at ORVIETO, magnificently situated on a crag in the Apennines. The *Cathedral*, in black and white marble, almost rivals that of Siena, with its glorious façade and majestic nave. The famous well with two staircases, lined with maidenhair.

ELEVENTH DAY. In two days many of the chief glories of ROME may be seen. The visitor who cannot stay longer should proceed thus the first day: *St. Peter's Cathedral*, the dome, the "Pietà," by Michael Angelo, the chair of St. Peter, the Confessio, with 89 ever-burning lamps, the Jubilee Door, in mosaic, etc. The *Vatican Palace*, the largest in the world, and the home of the Popes. Here is the celebrated *Sistine Chapel*, with the wonderful ceiling by Michael Angelo, and frescoes by great masters; and also the world-famed Raphael Rooms. The *Church of St. John Lateran*. The *Holy Staircase*. The *Church of St. Maria Maggiore*. The *Church of St. Paul Without the Walls*.

TWELFTH DAY. The second day in Rome should be given to the *Forum*, with its extraordinary excavations showing the central features of Ancient Rome; to the *Arch of Titus*, on which is sculptured the triumphal entry into Rome with the spoils of Jerusalem; the *Arch of Septimus Severus*; the *Baths of Caracalla*; *Trajan's Column*; and the majestic *Coliseum*.

THIRTEENTH DAY. At LEGHORN. The picturesque *Harbour*, with its views of Elba, Gorgona, and Capraja. The *Giardino dei Bagni*. The *Corso*, with its coral and mosaic shops. The colossal statues of *Carlo Alberto and Ferdinand III*.

FOURTEENTH DAY. The last day would be spent at TURIN. This city is the capital and crown of Piedmont. The noble *Superga Cathedral*, on a lofty hill outside the city, is the burial-place of the Princes of the House of Savoy. The grand, wide streets of Turin, the fine statues, the splendid shops, and the picturesque piazzas make a visit as interesting as it is delightful.

A Tour of Three Weeks. This would enable the visitor to Italy to enjoy an extension of his tour either to the other lakes—Garda, Maggiore, Orta and Lugano—or to the cities of Verona, Padua, and Venice. The former would take him into the scenes of the greatest beauty, while the latter would be of incomparable interest. The former is replete with everything that could delight the eye of the artist. The latter appeals to the classic student with irresistible charm.

A Tour of a Month. If at all possible, a month should be spent in Italy, and this would enable the traveller to include both extensions. Or he might choose one of them, either the lakes or the cities, for a week, and then spend the fourth week in Naples, taking in Capri, Pompeii, Sorrento, Pæstum, Amalfi, and Salerno. *Five* weeks would be ample for both the above extensions, and also this enchanting excursion to the South. *A sixth* week would make it easy to see [illegible] of Sicily, taking in Palermo, Messina, Taormina, Catania, and Syracuse. Those who can afford the time and the money may thus in six weeks traverse the whole length of Italy, and become acquainted with many of its fairest and most romantic scenes.

Expenses. The expense of Italian travel is not at all extravagant. The tourist should reckon that on an average he will require at least 15s. a day for travel and hotel expenses. If he chooses the finest hotels in Rome he will, of course, find his bills considerably heavier. But in the small towns the charges are often exceedingly moderate, and the distances from town to town are short if a single district be chosen. Besides the expense thus indicated is to be reckoned the fare from London to Milan: First class, single, £6 3s. 7d.; return £10 0s. 7d. Second class, single, £4 7s.; return, £7 2s 8d.

In no country is travel now made more comfortable than in Italy. All the cities of any size are well provided with tramways. Steam and electric roads connect the suburban towns with the larger cities. Cabs are cheaper in Italy than in either our own country or France. A cab with a single horse costs 1 franc a course by day, and a franc and a half by night.

Food. Food in Italy has some peculiarities. The coffee is almost universally largely mixed with chicory, but the decoction is very wholesome and is well prepared. The bread is everywhere of very good quality. "Macaroni con pomidoro" is a very popular and most delicious dish. It is a preparation of macaroni with tomatoes. Olive oil is used in countless articles of diet, and so are onions and garlic.

Books to Read. The entertaining literature on Italian travel is voluminous. We recommend the intending tourist to read Villari's "Here and There in Italy," Pennell's "Italian Pilgrimage," Hare's "Cities of Italy," Macquoid's "Pictures in Umbria," Egerton's "Hill Cities of Italy," Macmillan's "Roman Mosaics," Marion Crawford's "Ave Roma Immortalis," Ruskin's "Mornings in Florence," Mrs. Oliphant's "Makers of Florence," D. Pidgeon's "Venice," W. D. Howells' "Venetian Studies," A. J. C. Hare's "Walks in Rome," Dr. Alexander Robertson's "Bible of St. Mark's," Villari's "Italian Life," Mrs. King's "Italian Highways," etc.

Continued

FARADAY'S ELECTRICAL RESEARCHES

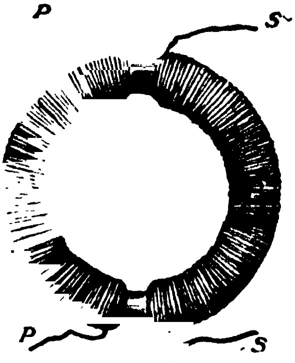
Group 10
ELECTRICITY
7

Continued from page [illegible]

Induction. Faraday's Ring the First Transformer. Attempt to Convert Magnetism into Electricity. Faraday's Primitive Dynamo

By Professor SILVANUS P. THOMPSON

Faraday's Researches. To Michael Faraday (1791–1867) more than to any other of the pioneers of electricity are electrical engineers, and, indeed, the whole world, indebted for the discoveries upon which the advances of modern times and the inventions of recent years are based. The chief discoveries which he made in electromagnetism, the foundation principles of all transformers and of all dynamos, were made in the autumn of 1831, the first fruits of his resolve to abandon the lucrative work of a professional expert in order to devote himself to scientific research. He had indeed already achieved fame by earlier researches, chief among them being the discovery of the electromagnetic rotations—the principle, in short, of electric motors—the chemical discovery of benzol and the liquefaction of chlorine. But it remained to him to discover, what had long eluded the grasp of the scientific experimenter—namely, the use of magnetism to generate currents of electricity. For at that date the only known ways of generating electric currents were (1) the chemical method in the voltaic cell, (2) the thermal method by the heating of the junctions of different metals, (3) the frictional method, as in the old glass electric machines. The first of these depended upon the consumption of zinc and acids in batteries; the second yielded very small electromotive forces, and was uneconomical; the third gave sparks and discharges rather than useful currents, and was unpractical. To these three Faraday added a fourth when he found that an electric current was generated in a copper conductor, mechanically, when the conductor was moved past the pole of a magnet, or when the magnet was moved near the conductor. Incidentally he discovered a great deal more than this; but the main point is that stated. For if we had had to depend on chemical action, thermal action, or friction, for our supplies of electric current, there would have been to-day neither electric light nor electric motive power. The public supply of electricity from central stations, and all the thousand applications in electrical engineering would have been quite out of the question.



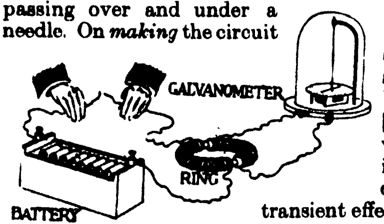
87. FARADAY'S RING

Induction. In the earlier-discovered phenomena of electricity the only known ways of producing a current in a copper wire had been by contact or conduction—the current could be conducted from one piece of metal to another. Also it was known that magnetism could be conducted along an iron bar by placing it in contact with the pole of a magnet. Conduction along the metallic substance from particle to particle was a familiar idea. It had also been known for half a century that an electric charge could be acquired by a body *by influence* from a pre-existing charge of electricity in another body, at a distance of a few inches apart, without any contact or communication between the two. To this phenomenon of action at a distance, discovered by John Canton, the name of *induction* had been given, to distinguish it from conduction. It was also known that magnetism could be imported, by influence, from a magnet to a neighbouring piece of iron without contact or conduction, and this was similarly called magnetic *induction*. But though one charge might induce another charge, and one magnet might induce another magnet, no one had ever been able to make an electric current induce another electric current, nor had anyone succeeded in causing a magnet to induce a current. Many philosophers had expected that some such relations would exist. They had tried to observe them experimentally. Faraday himself had both expected and experimented. In 1822 he wrote in his note book as a thing to be tried: "Convert magnetism into electricity." A splendid problem—but how to do it? In 1825 he tried several times, but without result, and again in 1828, for the fourth time, but fruitlessly. But in August, 1831, he began a systematic research, from which in a brief ten days of work, with intervals of contemplation and preparation between them, he emerged triumphant.

Induction from Wire to Wire. The idea, suggested by analogy, was that if there were two wires lying side by side, and if along one of them a powerful enough current were flowing, there would be some current induced in the neighbouring wire; but no experimenter, not even Faraday himself, had been able to observe such a thing. Again, it had been argued, by analogy (but incorrectly), that if an electric current circulating around a coil of wire, placed so as to surround a bar of iron could make that bar into a magnet (see page 562), then, as a deduction, if we were to put a powerful enough steel magnet inside such a coil of copper wire, the magnet ought to induce a current of electricity in the coil. But it did not when the experiment was tried. How to convert magnetism into electricity still remained a problem.

When Faraday set to work he began by coiling wires round wooden rods and wooden blocks; two wires, not touching one another, being carefully coiled side by side so as to lie close beside one another. He joined up one wire to a battery so that a current flowed along it. Then, joining up a galvanometer to the second wire, he looked to see whether any trace of current was "induced" in the second wire by the influence of the current in the first wire—and there was none. He varied the experiment in several ways, but obtained no success beyond a faint disturbance in the galvanometer, which occurred only if the galvanometer wire was joined up first, and the connection of the other wire to the battery was made afterwards; and then the disturbance was only momentary, at the instant when the battery connection was made or broken. As to any feeble current such as he had expected there was none. But the faint disturbance was a hint not lost on so keen an observer. It showed him that he must look for a transient effect, and to observe it the better he constructed new apparatus. This was tried on August 29th, 1831.

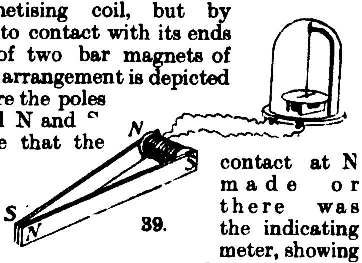
Faraday's Ring. Faraday had made a ring [87] of soft iron. It was forged by a blacksmith of iron rod ⅞ inch in thickness, and was 6 in. in external diameter. On this ring were wound two coils (A and B) of insulated copper wire; there being 72 feet in coil A, and 60 feet in coil B. This ring was used as follows. A battery of ten small cells was prepared to be connected to coil A, while coil B was joined to a simple galvanometer made of a coil of wire passing over and under a compass needle. On *making* the circuit between coil A and the battery [38] there was an immediate and transient effect on the galvanometer in the B circuit; its needle was deflected, oscillated, and finally settled down in its original position. On *breaking* the connection with the battery, the galvanometer again showed a temporary disturbance, but the deflexion was in the direction opposite to that of the deflexion which occurred on making the circuit. As the two coils A and B were quite separate, electrically, from one another, it was clear that the current in A had *induced* currents in the coil. It was also clear that the iron ring had a share in the operation. In fact, when the current in A was turned on, the circulation of the current in the A coils had magnetised the ring; and when the current in A was turned off, the iron ring had ceased to be a magnet.



38.

The magnetism of the iron core had obviously acted on the coil B, and had inductively generated currents in it.

Induction by Steel Magnets. On the third day of the experiments Faraday varied the plan of experimenting as follows. He had seen that in the ring experiment the magnetism made by coil A was evidently the agent which acted on the coil B; and he tested the matter by changing the apparatus so as to use the magnetism of common magnets of steel instead of the coil A, which, with its part of the ring core, had acted as an electromagnet. Accordingly, he connected the galvanometer by wires to a new B-coil not wound on a ring, but wound on a short cylinder of soft iron; and magnetism was imparted to this core not by any magnetising coil, but by bringing into contact with its ends the poles of two bar magnets of steel. The arrangement is depicted in 39, where the poles are marked N and S Every time that the magnetic contact at N or S was made or broken, there was motion in the indicating galvanometer, showing the presence of transient induced currents in the coil. Hence, as Faraday records, here was a distinct evolution of electricity by the aid of magnetism.

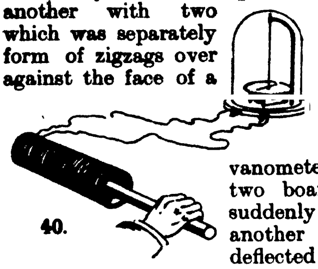


39.

Motion Essential. The circumstance that these effects were transient, and that no current, not even the feeblest, was generated while the magnets remained in contact, explained the failure of so many previous attempts. The missing factor in all the futile attempts had been motion, or what was its equivalent, change in the magnetic state. The magnet *at rest*, or the electric current flowing with uniform intensity, produced *no inductive action* on the neighbouring copper wire. The magnet must move, or it induced no current. The current in coil A of the ring must equally not be a current at rest; it must be a current that is growing in strength, or a current that is in the act of dying, if it is to act inductively; for it is only while the current is changing its strength that the magnetism due to it undergoes change.

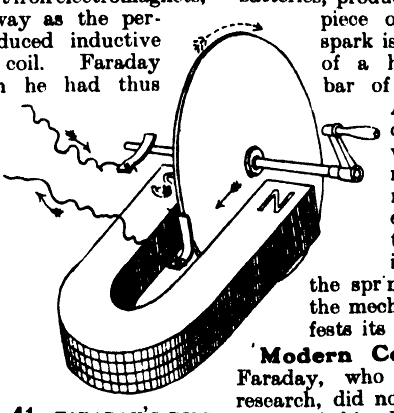
Movement of the Magnet. On the fifth day Faraday used a hollow cylindrical coil made by coiling 220 feet of wire around a pasteboard tube. This coil was joined up to the galvanometer. He then took a cylindrical bar magnet of steel 8½ in. long, and ¾ in. thick. On plunging it [40] into the coil the galvanometer needle made a quick movement to one side, and then returned to its zero. On pulling the magnet out, the needle again moved, but in the opposite direction. Here, evidently, an electromotive impulse was *induced* by mere approximation of the magnet, and not, as in the case of the iron ring, by formation of the magnetism in the stationary iron. Further, as the magnet used in the operation lost none of its magnetism during use, the energy which propelled the current must have been derived from the movement of the arm. It was the *mechanical generation* of a current by the expenditure of energy rather than any conversion of magnetism into electricity.

Faraday followed up this experiment by another with two coils, each of which was separately stretched in the form of zigzags over wooden pegs against the face of a board. The A coil was joined to a battery, the B coil to a galvanometer. When the two boards were moved suddenly towards one another the needle was deflected; when they were moved asunder the needle was deflected in the opposite direction. Soft iron electromagnets, when used in the same way as the permanent magnets, also produced inductive effects in a neighbouring coil. Faraday christened the phenomenon he had thus discovered by the name of *magneto-electric induction.*



40.

Faraday's Primitive Dynamo. On the ninth day of Faraday's experiments he was able to construct a "new electrical machine." Borrowing the most powerful compound magnet he could procure, he affixed to its poles, in order to concentrate its magnetism, two pole-pieces of iron set about ½ in. apart. Into this polar gap, where the magnetic field was strongest, he introduced a wheel or disc of copper, 12 in. in diameter and ⅕ in. thick, fixed on a brass axis mounted in frames so that it could be revolved. Against the edge and axis of this revolving disc he pressed collectors of springy metal, and these he connected by wires to the galvanometer. Fig. 41 shows the apparatus. On revolving the disc by hand a current was continuously generated, which produced in the galvanometer a steady deflexion. The direction of this deflection was reversed when the direction of rotation was reversed. "Here, therefore," he records, "was demonstrated the production of a permanent current of electricity by ordinary magnets."



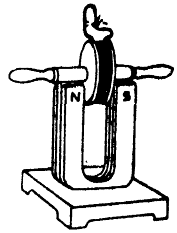
41. FARADAY'S DISC DYNAMO

This was the first primitive *dynamo.* The name, however, of *dynamo-electric machine* was not used till 1867, when Brooke coined it to connote all such machines. "A dynamo-electric machine will be one in which dynamic energy is employed to produce an electric current."

Faraday further pointed out the important part in all these experiments and apparatus played by the invisible *magnetic lines* (p. 560) of the magnets. He showed that in order to create any of these inductive effects the copper conductors must so move as to cut across the magnetic lines, or else the magnets or magnetic lines must so move as to "cut" by the copper conductors. In fact, the induced electromotive force is proportional to the number of magnetic lines cut per second.

Spark from a Magnet. In these splendid ten days Faraday had harvested a crop of new facts, new relations, and new principles, destined to immense development. He did not rest till he had shown that these induced currents could, like the currents from batteries, produce sparks and shocks. A simple piece of apparatus for generating a spark is depicted in 42. On the poles of a horse-shoe magnet rests a short bar of iron, provided with handles. Around the bar is wound a coil of wire, one of the ends of which is connected to a spring, making contact lightly against a metal button joined to the other end. On suddenly snatching this coil off the magnet a current is generated in the coil, and as the spring chatters at its contact with the mechanical shock, the current manifests its presence by a tiny spark.

Modern Commercial Development. Faraday, who devoted himself to pioneer research, did not push the commercial applications of his discoveries. "I have no time to make money," he explained. He ended this epoch-making research with the memorable words: "I have rather, however, been desirous of discovering new facts and new relations dependent on magneto-electric induction, than of exalting the force of those already obtained; being assured that the latter would find their full development hereafter."



42. FARADAY'S SPARK APPARATUS

That "full development hereafter" we see in the thousands of dynamos, alternators, magneto-generators, motors and transformers which furnish light and power by electricity for the use of mankind all the world over. It was the self-denying genius of Faraday which made them possible.

Continued

Group 25
PHYSIOLOGY
7

Continued from page 867

CIRCULATION OF THE BLOOD

Characteristics and Use of Blood. Its Composition. Function of the Corpuscles. Blood-vessels and their Work. The Heart and its Action

By Dr. A. T. SCHOFIELD

JUST as beneath our streets are three sets of pipes conveying gas, water, and sewage, so throughout the body are three descriptions of vessels coloured, by the fluid within them, red, white, and blue. The red vessels convey arterial blood from the heart; the blue return venous blood to the heart; and the lymphatics convey the drainage of the body cells into the venous blood near the heart, together with the digested fat from the food. These three sets of pipes are very numerous, and present many complications, which we will consider presently. Our first business is to examine the blood which flows through the vessels, then to consider the vessels, and lastly, to describe the heart that pumps the blood throughout the body.

The Blood—the Life of the Body. All the life of the body depends upon the quality and regular circulation of the blood. Our thoughts, our powers, our actions, depend upon its regular supply in proper quantity and quality to every part and every organ of the body. The brain is particularly sensible to any failure in the blood supply, and special arrangements are made there that nothing may interfere with its circulation. The blood, then, is a *heavy*, *red*, *opaque*, *warm*, *alkaline*, *saltish* fluid, with sometimes a faint odour characteristic of the animal to which it belongs. It is emphatically a living fluid, not only in the sense that upon it, as we have said, depends the existence of the body, but because it is full of life. It is the sole means, as we have seen, by which the varied and complex products of digestion, on the one hand, and oxygen, on the other, are conveyed to all the tissues and to every body cell, there to be reduced to simple forms of a less complex nature, the force liberated in the process being partly used in the passive life of the cells, and partly in the various active phenomena. The blood is, therefore, with the aid of the lymph, the carrier between the digestive and respiratory organs, on the one hand, and the living body cells, on the other, the blood-vessels forming, at the same time, a complete warming apparatus for the body. Blood is *heavy* as compared with water, the one having a specific gravity of 1,000, the other of 1,056.

Colour and Heat of Blood. The *colour* of blood varies from bright scarlet to dark purple. In the *arteries*, and also whenever exposed to the air, it is bright red. Hence, it is bright red in the superficial capillaries just beneath the surface of the cheek, and wherever the skin is thin enough to receive oxygen from the air.

In the *veins* it varies from dark purple to red, getting brighter in proportion to the activity of the part or organ whence it comes. It also presents different colours, being red by reflected light, and green by transmitted light. The blood is opaque, owing to its being a mixture of solids and liquid.

The average *blood* heat near the surface of the body is 98·4° F., and is about the same in health in all temperatures, "warm-blooded" animals, as we have seen, having constant blood-heat, independent of their surroundings, in contradistinction to "cold-blooded" animals, whose blood is not necessarily "cold," but varies with the surrounding medium.

The temperature of the blood in the deeper vessels is said to range between 100° and 107°. Its temperature is also increased in passing through large glands, notably the liver.

The blood is *alkaline* in life, but out of the body it soon becomes neutral, and then acid. It is saltish from the presence of common salt.

The *quantity* of the blood may be taken as about one-thirteenth of the weight of the body, a quarter of which is contained in the heart, lungs, and larger vessels; a quarter in the liver and its vessels; a quarter in the muscles, and a quarter in the circulatory vessels.

Composition of Blood. Blood consists, as we have said, of both a solid and a liquid. The solid part consists of small bodies called *corpuscles*, the liquid of a fluid called the *liquor sanguinis*, or *plasma*.

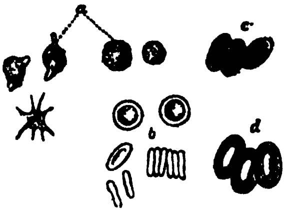
Two great varieties of blood corpuscles are generally recognised—the red and the white, or, more correctly, the colourless [39].

The blood is one-third solid, or corpuscles, and two-thirds liquid, or plasma.

The *red corpuscles* outnumber the white by about 500 to 1, and differ from them, not only in colour and size, but in being always round, which the white ones never are so, save in death. The red are about $\frac{1}{3200}$ of an inch in diameter, but are so numerous that it has been computed there are five million in every cubic millimetre (less than $\frac{1}{25}$ in.), and that the corpuscles in a man, spread out flat, would cover and colour red a space something like 30 square miles. They are round and biconcave, or discoid, that is, thinner in the centre than at the sides. They are soft, flexible, and elastic, and can squeeze almost anywhere. When the blood is drawn or clotting, the red corpuscles have a great tendency to run together in rouleaux, like piles of coin.

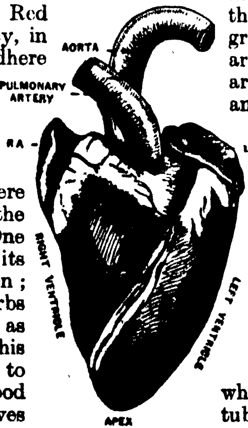
In fish and camels, these corpuscles are oval instead of being round; but there is no special distinction between human corpuscles and those of the higher animals, so that it is almost impossible to prove that a blood-stain is human.

175 Millions a Minute. Red corpuscles are quickly produced after severe loss of blood, and are said to be renewed at the rate of 175 million a minute. They are largely formed from the marrow in bones, in the spleen, and elsewhere; they differ from body cells in their shape, having no visible nucleus or central part that is darker than the rest. They are 60 per cent. water. Their average length of life is two weeks, during which they are filled with oxygen in the lungs, and emptied in the tissues some 20,000 times. They are destroyed chiefly in the liver, where they help to form the bile. Thus, in the body, nothing is wasted.



39. VARIOUS BLOOD CORPUSCLES
a. Human white blood corpuscles, some with processes. *b*. Human red blood corpuscles. *c*. Oval blood corpuscles of bird. *d*. Blood corpuscles of a frog

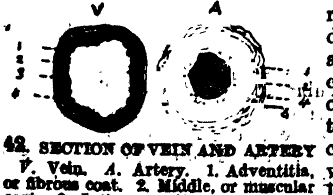
The red corpuscle is composed of a framework of protoplasm, holding in its meshwork a transparent viscid substance called *hæmoglobin*. It often swells up and becomes more or less spherical. It is exceedingly elastic, and more numerous in the male than in the female. Red corpuscles have a great tendency, in some conditions of the blood, to adhere together or change their shape. They are yellowish in colour, and only show the red tint of blood when seen in masses [40].



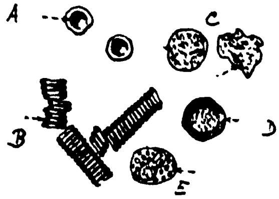
43. THE HEART
Showing the front external view with the aorta

Their numbers rapidly diminish in certain diseases. In anæmia there may be only one-fourth of the number present in health. One characteristic of hæmoglobin is its remarkable affinity for oxygen; owing to this the blood absorbs twelve times as much oxygen as water. The hæmoglobin holds this gas in a very loose form, so as to part with it readily. As the blood passes through the lungs it receives oxygen, and the hæmoglobin becomes an *oxyhæmoglobin*, as in arterial blood; then, again, as it reaches the tissues, the oxygen leaves it, and it is reduced to hæmoglobin. It is in this way that blood is the great oxygen carrier of the body. Hæmoglobin forms 90 per cent. of the bright red corpuscles. It is a crystalline body, and its one and special function seems to be to convey oxygen.

White Corpuscles. The colourless, or *white corpuscles* (discovered by Hensen, 1773), are larger than the red ($\frac{1}{2500}$ in. diameter), but are only spherical in death; during life their shape constantly varies [41]. Like the red corpuscles, they have no cell-walls, but, unlike them, they have one or more distinct nuclei. They have a finely granulated appearance, which, on examination under a higher power, is seen to be due to a meshwork that pervades them, the corners of the meshes being formed into knobs; part of the granules may be food material. The colourless corpuscles, or leucocytes, of the blood are identical with the smaller description of lymph cells that are found all over the body, and particularly in the spleen and lymphatic glands. The function of these cells has long been doubtful, and is only now beginning to be understood. They have very active habits during life. Possessing the power of traversing the walls of the blood-vessels with the greatest ease into the lymph space around, or into the body tissues, they are found in enormous numbers wherever any active inflammation is going on, and they form the principal part of pus or "matter."



42. SECTION OF VEIN AND ARTERY
V. Vein. *A*. Artery. 1. Adventitia, or fibrous coat. 2. Middle, or muscular coat. 3. Intima, or living membrane. 4. Neuclei of cells of intima



40. CORPUSCLES
A. Red corpuscles. *B*. Red corpuscles in rouleaux. *C*. White corpuscles. *D*. White corpuscles with nucleus. *E*. White corpuscles, with nucleus and granules

Enemies of Bacteria. Professor Metschnikoff, of the Pasteur Institute, regards white corpuscles as our defenders against microbes of all sorts, and has lately shown how active they are in eating and destroying bacteria and germs, and also refuse of all kinds; while the curious fact has been discovered that from Peyer's patches in the intestine, where they abound, they migrate into the tube, seize on all the bacteria they can find, and carry them down into the deeper tissues, where they and their spoil both become the prey of a larger description of lymph corpuscle, called giant cells.

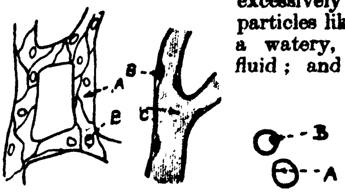
Enough has been said to show what a life of varied interest and usefulness white corpuscles lead, and to encourage us to hope for still further discoveries respecting them. They increase rapidly by fission, which the red corpuscles never do, and appear in amazing quantities in a very short time wherever they are wanted. The spleen is one great source of their origin, and in the splenic vein they number 1 to 80 of the red corpuscles.

The most remarkable feature about these corpuscles is their constant change of shape (which is

41. CORPUSCLES UNDER THE MICROSCOPE
Living white corpuscles changing shape under the microscope

always very irregular) by *amœboid* movements, so-called from their similarity to those of the *amœbæ* of stagnant waters. The great distinction between these and the red corpuscles is that the power of the former is distinctly vital; their change of shape is certainly of set purpose, as when they enclose a particle of food; they probably exercise, too, some distinct influence over the plasma, whereas the red corpuscles are merely oxygen carriers.

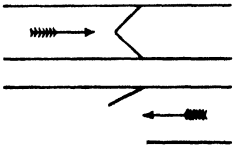
45. VEIN VALVES
Longitudinal section through a vein, showing valves



47. CAPILLARIES
1. Longitudinal sections. 2. Transverse section. *A*. Cells of single wall. *B*. Nuclei of cells. *C*. Branch of capillary

The Properties of Blood. The *plasma*, or liquid part of the blood, is nine-tenths water, is of a yellowish colour, and contains carbonic acid gas, albumen, fats, glycogen (liver sugar), and salts.

It has, because of other bodies contained in it, a most remarkable power of *clotting* or coagulating — a process, indeed, on which our life depends. As will be seen in the section on ILL-HEALTH, there is a class of people in whom this clotting power is either wholly absent, or so feeble as to be useless, and these people are in imminent danger of bleeding to death, even if a tooth is extracted.



46. VALVES IN VEINS, OPEN AND CLOSED

Huxley gives the following simple experiment to demonstrate this power of clotting:

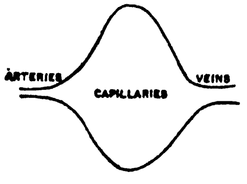
"Twist a piece of string pretty tightly round the middle of the last joint of the middle or ring finger of the left hand. The end of the finger will immediately swell a little, and become darker coloured, in consequence of the obstruction to the return of the blood in the veins caused by the ligature. When in this condition, if it be slightly pricked with a sharp, clean needle, a good-sized drop of blood will at once exude. Let it be deposited on a slip of thick glass, and covered lightly and gently with a piece of thin glass, so as to spread it out evenly in a thin layer. Let a second slide receive another drop, and to keep it from drying let it be put under an inverted wine-glass, with a bit of wet blotting-paper inside. Let a third drop be dealt with in the same way, a few granules of common salt being first added to the drop.

44. ARTERIAL AND VENOUS SYSTEM OF THE BODY

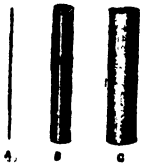
"To the naked eye the layer of blood upon the *first slide* will appear of a pale reddish colour, and quite clear and homogeneous; but, on examining it with a pocket lens, its apparent homogenity will disappear, and it will look like a mixture of excessively fine, yellowish-red particles like sand or dust, with a watery, almost colourless, fluid; and immediately after the blood is drawn, the particles will appear to be scattered very evenly through the fluid, but by degrees they aggregate into minute patches, and the layer of blood becomes more or less spotty."

48. NETWORK OF CAPILLARY BLOOD VESSELS

The particles are the red corpuscles of the blood; the nearly colourless fluid in which they are suspended is the plasma.



49. ARTERIES, CAPILLARIES, AND VEINS
Sectional area



50. RELATIVE SIZES
A. Capillaries. *B*. Arteries. *C*. Veins

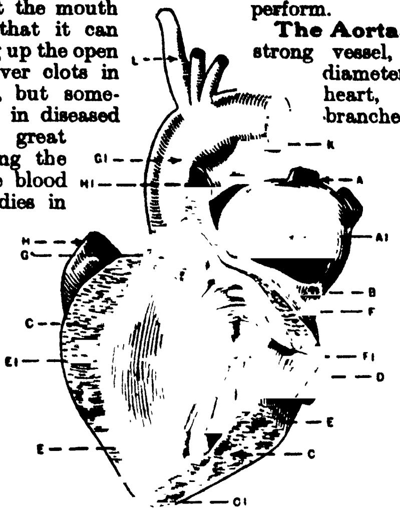
The *second slide*, prepared as described above, may now be examined. The drop of blood will be unaltered in form, and perhaps may seem to have undergone no change. But if the slide be inclined, it will be found that the drop no longer flows, and, indeed, the slide may be inverted without the disturbance of the drop, which has become solidified, and may be removed with the point of a penknife, as a gelatinous mass. The mass is quite soft and moist, so that this setting or *coagulation* of a drop of blood is something quite different from its drying.

On the *third slide* this process of coagulation will be found not to have taken place, the blood remaining a fluid as it was when it left the body. The salt, therefore, has prevented the coagulation of the blood. Thus this very simple investigation teaches that blood is composed of a nearly colourless plasma in which many coloured corpuscles are suspended, and that this coagulation may be prevented by artificial means, such as the addition of salt.

The coagulation is brought about by the changing of a part of the plasma into a branching mass of fibrous tissue called *fibrin*, in the meshes of which myriads of the red corpuscles are entangled.

Why Blood Clots. As the clot is thus formed, a thin straw-coloured fluid is squeezed out, called the *serum*, which is practically plasma deprived of its fibrin. The value of this clotting power is, of course, in its solidifying the blood at the mouth of a cut artery or vein, so that it can no longer flow, thus stopping up the open end of the vessel. Blood never clots in a healthy vessel during life, but sometimes the blood may clot in diseased veins, and thus become a great source of danger by blocking the circulation. Clotting in the blood is hastened by any solid bodies in the blood, by heat at 100° F., by being stationary, by the action of air, by deficiency of water, by injury or disease of vessels. It is deferred by increase of water, cold or great heat, by an alkaline solution (salt), and by being in living blood-vessels. Arterial blood clots more quickly than venous blood.

On the whole, blood has a similar chemical composition to that of muscle. The gases in the blood are as follow: *Oxygen*, 20 per cent. in arteries and 10 per cent. in veins, all carried in the red corpuscles; *carbonic acid gas* in arteries, and 47 per cent. in veins, all carried in the plasma; *nitrogen*, 1 or 2 per cent. vol.

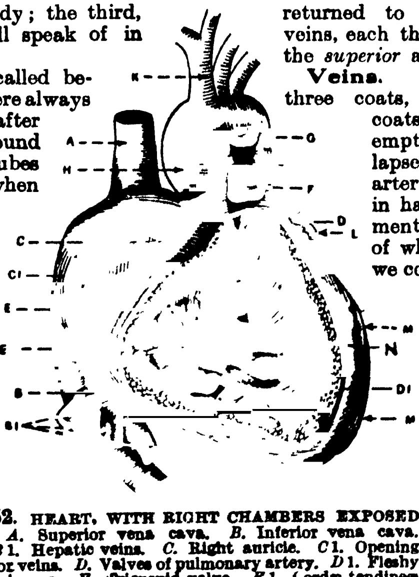


51. HEART, WITH LEFT CHAMBERS EXPOSED

A. Pulmonary veins. *A* 1. Left auricle. *B*. Wall of auricle. *C*. Wall of ventricle. *C* 1. Apex of heart. *D*. Fleshy column attached to valve. *E*. Musculi papillares and cordæ tendineæ attached to valve. *E* 1. Left ventricle. *F*. Mitral valve. *F* 1. Opening of valve. *G*. Semilunar valves of aorta. *G* 1. Aorta. *H*. Pulmonary artery. *H* 1. Pulmonary artery. *K*. Attachment by ductus arteriosus to aorta. *L*. Arteries to head and arm

The Blood-vessels. We now turn to the blood-vessels, which include two out of the three sets of pipes in the body; the third, or the lymphatic, we shall speak of in the next chapter.

The *arteries* [42] are so called because by the ancients they were always supposed to contain air, as after death they were always found empty. They are stout tubes that remain round even when empty, and are made of three coats, the outer (the *adventitia*) being fibrous for protection, the middle (the *muscular*), to regulate the size of the vessel, and the inner one (the *intima*), a delicate membrane of living cells which have many active functions to perform, not least of which is to aid in removing impurities, germs and the like, from the blood. So that we must distinctly understand that there is nothing dead or mechanical about either the blood or blood-vessels. The former is filled with active living white corpuscles; the latter lined with many active living cells, which have definite work to perform.



52. HEART, WITH RIGHT CHAMBERS EXPOSED

A. Superior vena cava. *B*. Inferior vena cava. *B* 1. Hepatic veins. *C*. Right auricle. *C* 1. Opening for veins. *D*. Valves of pulmonary artery. *D* 1. Fleshy columns. *E*. Tricuspid valve. *E* 1. Cordæ tendineæ attached to valve. *F*. Pulmonary artery. *G*. Attachment to aorta. *H*. Aorta. *K*. Vessels from aorta. *L*. Appendix of left auricle. *M*. Left ventricle. *N*. Right ventricle

The Aorta. The arteries begin in one strong vessel, the *aorta* [43], 1 in. in diameter, which, as it leaves the heart, soon subdivides into six branches—two for the head, two for the arms, and two for the legs. These divide and subdivide as they run along the protected inner sides [44] of the limbs and all over the body, like the branches of a tree, till the tiniest twigs are so small that they can hardly be seen by the naked eye, and these are called *arterioles*.

Arteries are elastic and, always being a little overfull, they are ever on the stretch, and so maintain that gentle pressure on the blood that keeps up the flow between the beats of the heart. When an artery ruptures, the inner coat folds over inwards as it contracts, and thus at once begins to stop the flow of blood.

A short distance from the end of the *arterioles* the smallest *veinlets* begin, and rapidly uniting form large trunks which lie alongside of the arteries, until at last the united volume of blood is returned to the heart by two great veins, each the size of the aorta, called the *superior* and *inferior* vena cava.

Veins. *Veins*, like arteries, have three coats, but, unlike them, these coats are so thin that an empty vein flattens and collapses. They also differ from arteries, especially in the limbs, in having a remarkable arrangement of valves [45], the value of which will be apparent when we come to speak of the circulation. These valves are in pairs, an inch or so apart, and are made to open towards the heart, so as to afford no obstruction to the progress of the blood in that direction [46], but to close at once if it tries to turn back. The walls being thin, they more easily bulge under pressure than those of arteries.

Capillaries. Until 1661 this was all that was known of the blood-vessels, and it was believed

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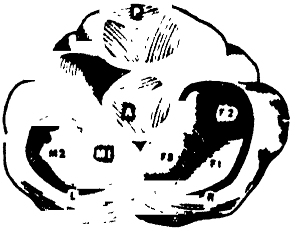
that the blood was poured out into the tissues by the arteries, to be picked up a short distance off by the veins. It was then discovered, however, that between the two an intricate network of tiny microscopic blood-vessels (called *capillaries*) exists, some $\frac{1}{3000}$ of an inch in diameter [47] extending all over the body in such inconceivable numbers that it is almost impossible to insert the point of a pin anywhere without piercing one of them [48]. The whole body thus consists of tiny islets of cells surrounded by capillaries, which themselves lie in lymph channels. These tiny vessels have but one coat, but as we have fully described them and their remarkable functions in the last chapter, we need not recapitulate here. They extend to thousands of miles. If the arteries begin in one tube 1 in. in diameter, and the veins end in two tubes with a united calibre of 1½ in., the united calibre of the capillaries is represented by a tube of about 2 ft. in diameter [49].



53. VALVES OF THE HEART

A transverse section. *A.* Aorta. *P.* Pulmonary artery. *M* 1 & 2. Two flaps of mitral valve. *F* 1, 2, & 3. Flaps of tricuspid valve. *L.* Left side. *R.* Right side

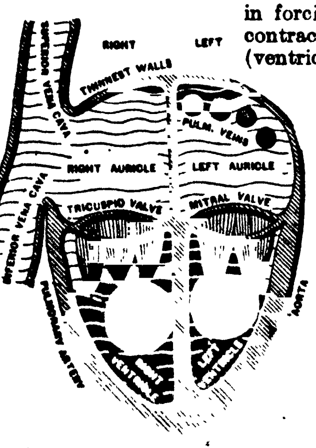
The Heart. We must now proceed to describe the mechanism by which the circulation of the blood is maintained by the elaborate pump called the heart.

The *heart*, enveloped in the double layer of the *pericardium*, is in the form of a blunt, hollow cone about the size of its owner's fist. It weighs about 9 oz., and is situated behind and somewhat to the left side of the lower half of the *sternum*, or breast-bone. Its base is uppermost and to the right, its apex being downwards and towards the left. It consists, like the arteries and veins, of three coats; an outer fibrous coat, called the pericardium, which really consists of two layers, forming a closed sac, the heart being folded up in it. The inner layer is closely adherent to the heart, and the outer layer to the connective tissue around, a small amount of fluid being between the two.

An illustration may help us to understand how the pericardium is arranged. Take two thin paper bags, of which one is slightly smaller than the other, so that one may be contained within the other, both being fully distended. Now slightly fold back the edge of the mouth of the inner bag, and gum it all round to the edge of the mouth of the outer one. There is now a double bag made with an inner and an outer layer, and a small space between them, completely shut off from the outside. Suppose the closed fist to be just large enough to fill the inner bag, it will represent the heart, to which the inner layer of the pericardium is adherent. The wrist will represent the great vessels passing off from the heart, around which the neck of the double bag extends. All the serous membranes which enclose the various organs are made on the same principle—around the brain, lungs, and digestive organs.

Muscles of the Heart. The *middle*, or muscular coat, forms the main substance of the heart itself, and in a muscular man varies from a quarter of an inch to an inch in thickness; while the *inner* coat is the lining membrane of the heart.

The muscle is peculiar, for the fibres are intermediate between the striped, or voluntary, muscles of the limbs and the unstriped, or involuntary muscles, of the arteries. They have transverse stripes and contract altogether like the former, but are not under the control of the will, thus resembling the latter. They are arranged in circular, oblique, longitudinal, and (towards the apex) in spiral layers. They continue for some distance along the two large veins. The fibres that surround the upper half of the heart are distinct, and can contract separately from those around the lower half. The muscular coat varies immensely in thickness. It is thinnest around the upper half of the heart on both sides (the auricles), because the work here is slight and only consists in forcing the blood, as the auricles contract, into the two lower cavities (ventricles). It is twice as thick on the lower right side, for this has to do twice as much work in pumping the blood through the lungs; and it is more than twice as thick again in the left lower half, because this ventricle has to pump the blood all over the body. The thickness of the muscle everywhere is in proportion to the amount of work it has to do.



54. DIAGRAM OF THE HEART

On right side two vessels enter and one leaves it. On left side four vessels enter and one leaves it

Chambers of the Heart. Inside, the heart in man is divided longitudinally into two halves, right and left; each half is again divided transversely, thus making four chambers in all [54]. In fish there are but two, in a frog three, while in the crocodile upwards, we get four. All these stages are passed through in the human embryo [51].

The two upper chambers are called respectively the right and left auricles, because on the top of each is a small flap like a dog's ear, and *auricula* means a little ear. They have very thin muscular walls. The two lower ones are called the right and left ventricles (*ventricula*, a little belly), and have much thicker walls; the left being also at least three times the strength of the right. Each chamber holds about four tablespoonfuls of blood. There is no direct communication between the right and the left side of the heart after fœtal life.

Trap-doors of the Heart. Each auricle communicates with the ventricle below by a sort of large trap-door in the floor, which on the right side consists of three flaps, and is called the *tricuspid valve*, and on the left of two and is called the *mitral* or *bicuspid valve*.

The right auricle has, in addition to this valve, the large opening (*sinus venosus*) common to the terminal veins [52].

In the right ventricle is the opening of the *pulmonary artery* which conveys the blood to the lungs to be purified, guarded by a *semilunar valve* which has three flaps. The centre of each margin has a little node (the *corpus arantii*), the three meeting when the valve closes. The bulging of the wall of the artery behind the valve is called the *sinus of Valsalva*. The parts in the aortic semilunar valves are similarly named. The left auricle has four openings for the four *pulmonary veins* that return the purified blood from the lung to the heart; and in the left ventricle is the large opening of the *aorta*, by which the blood finally leaves the heart, guarded by a *semilunar valve*, which has three flaps as in the right ventricle.

There are thus in the heart [53] three valves with three flaps (two semilunar and one tricuspid), and one with two flaps (the mitral). The arrangement of all these valves is such that the blood can only pass in one direction, always from the venæ cavæ towards the aorta. The orifices of the valve are strengthened by thick, fibrous rings, while the flaps of the tricuspid and mitral valves are stiffened and prevented from rising too far by strong bands (*musculi papillares*) and cords (*cordæ tendineæ*) fixed from the inner surface of the ventricle to their lower side. Fleshy pillars (*columnæ carneæ*), from which these cords spring, are also seen on the inner surface of the heart.

The two arteries (pulmonary and aorta) come from the front of the heart, while the six veins, two venæ cavæ and the four pulmonary veins, enter at the back. There are thus eight large blood-vessels connected with the heart, three with the right side and five with the left. On the right the two venæ cavæ returning blood from the body to the right auricle, and the pulmonary artery (the only one in the body conveying venous blood) carrying the blood from the right ventricle to the lungs. Then on the left the four pulmonary veins from the lungs enter the left auricle, and the aorta leaves from the left ventricle.

Action of the Heart. The heart contracts by nervous mechanism in the organ itself, and this is regulated by the brain. The heart muscle alone has a remarkable inherent contractile power, which is dependent on no external nervous energy nor even on the nerve centres in the heart, nor on blood in the heart. Contraction has been seen in bits of freed heart muscle, and appears to be absolutely *automatic*. No other muscle has this power, and there is no other muscle even in appearance like the heart muscle.

The heart as a whole, cut out from the body but supplied with blood, will beat for days. If supplied with oxygen instead of blood, for twelve hours; if with air, for three; if in a vacuum, for half an hour; if with CO_2, in each case it stops. There are in the heart three or more nervous centres from which undoubtedly energy is supplied; and bits of muscle containing them beat much more vigorously than those without.

Then besides this, the frequency of the contraction is regulated by two nerves. The one, the *pneumogastric*, slows the beat, and pressure on it may stop the heart altogether; the other, the *sympathetic*, accelerates it, and the influence of the emotions, causing the heart to beat more quickly under excitement, explains how that organ came to be regarded as the seat of the affections, with which it has really nothing to do.

The heart has no nerves of sensation, and hence it can feel nothing, and such a thing as pain *in* the heart is impossible. Even in angina, the only painful heart disease, the spasm is believed to be in the arteries and especially in those arteries (the coronary) that supply the walls of the heart itself with blood.

The heart on rare occasions is transposed and may be found beating on the right side of the body instead of the left. In disease it is frequently greatly enlarged.

Continued

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FRICTION & ITS APPLICATIONS

Theory and Laws of Friction. Mechanical Uses of Friction, including Brakes, Belt-hammers, Clutches, Gears, Shafting, Belts

By JOSEPH G. HORNER

Friction. No substance exists which has, or can have, a perfectly smooth surface. The polished face of a piece of wood or stone, or the surface of glass, is covered with minute roughnesses, although this unevenness is imperceptible to the senses of sight and touch. Thus, when two surfaces are in contact, the multitudinous protuberances interlock, resisting both the setting in motion and the continuance in motion of one surface over the other. This resistance is called friction. It destroys, but cannot generate motion, and it acts always in the contrary direction to that in which the body is moving.

How does the engineer regard friction ? Sometimes this force acts as a valuable ally in promoting the stability of a structure or in assisting the work of a machine, and it may even be necessary to assist this force in its tendency to resist slipping. To friction we are indebted for the action of the driving-wheels of locomotives, for they would otherwise slip on the rails and make no progress ; for the action of cords and straps round pulleys and drums ; for the gripping power of a vice ; for the arresting power of a brake ; and so on. Sometimes, however, friction is distinctly disadvantageous, and presents an obstruction to the efficient working of a machine. The ingenuity of engineers is then called into play to reduce its inimical tendency. Thus, roller and ball bearings assist the rotation of a shaft, while oils and tallow are extensively used as lubricants. Even then continual friction gradually abrades the hardest material, and so, in a machine where two parts are exposed to friction, that one which can be more easily or cheaply replaced is made of softer metal, so as to receive the greater degree of wear.

Kinds of Friction. The force tending to prevent the setting in motion of two bodies at rest is called *static friction*, and the resistance tending to arrest the motion of one body over another is *kinetic friction*. A distinction is also drawn between *rolling* friction, as in the revolution of a cart-wheel, and *sliding* friction, as in the motion of the same wheel going down hill with a skid on. It might be thought that the resistance between any two surfaces would be similar, whether they were at rest or in motion, but we shall see later on that this is not so. The word friction (Lat. *frico*—I rub), used in the statical sense, is scarcely exact, for there is no rubbing until motion commences.

How to Measure Friction—Coefficient of Friction. The amount of static or kinetic friction between any two bodies may be measured by a simple experiment. Suppose it is required to measure the frictional resistance between the weight W [**105**] and the surface A B along which it slides. The cord runs over a delicate pulley (C), and is attached to the scale pan. Weights (P) are gradually added until W starts moving. The weight required to do this measures the friction between the surfaces ; that is, P = the frictional resistance. In this experiment W = 10 lb., and P = 4 lb. Thus the ratio between the friction and the weight $\frac{P}{W}=\frac{4}{10}=\cdot 4$. This fraction is called the *coefficient of friction*, and if W and A B were composed of oak, then $\frac{4}{10}$ or ·4 would be spoken of as the coefficient of friction for oak on oak.

The coefficient obtained in this experiment should more correctly be termed the static coefficient, because P measures the greatest frictional resistance the bodies are capable of offering to a sliding force when at rest. If the surface (A B) is sufficiently long, it will be found that a *less* weight will be necessary to cause W to continue in uniform motion along A B if this steady motion is started with a slight push of the finger. In other words, static friction is greater than kinetic friction. A horse which has a difficulty in starting a heavy load pulls it with comparative ease once it is in motion. Actual experiment has shown that the static coefficient of dry wood on dry wood is ·50, but the kinetic coefficient is only ·36 ; similarly, the coefficient of dry wood on metal is ·60 at rest, but when in motion, ·42. If in this experiment the student substituted other substances and other surfaces, it would be found that a less weight or power would be required to start W in motion when the surfaces were smooth, and a greater power when the surfaces were rough. Hence, the fraction $\frac{P}{W}$ would become greater or less, according as the frictional resistance was greater or less. So we find that the coefficient of friction of wrought iron on oak is ·62, but that of steel on glass is ·11 ; of brick on brick ·64 ; but polished marble on polished marble ·16.

Another and simpler method of finding both static and kinetic coefficients is shown in **106**. W is the weight resting on a board (A B). One end of the board is very gradually raised until W slides down with uniform motion (for determination of kinetic friction), or until the weight is just about to start moving by itself (for static friction). When these points have been arrived at, then the ratio between the height and base of the plane gives the coefficient of friction. In the diagram the height is 8 and the base 30. Therefore the coefficient is $\frac{8}{30}$ or ·26.

Angle of Friction. In the last experiment the angle at A which the board makes with the horizontal surface A C is called the *angle of friction*, the *angle of repose*, or the *limiting angle of resistance*. As in the previous case, it will be found that this angle is less when the board is so inclined as to permit of steady and uniform motion of W than when the weight is about to start moving. The angle of friction may be described, then, as the angle made by a plane with a horizontal surface at the moment when a body that is placed on the inclined plane begins to slide. The amount of frictional resistance of any substance may thus be considered and stated, either as regards its angle of friction or its coefficient. Generally, both these relations are stated. The following are interesting examples:

Substances.	Coeff. of frict.	Ang. of frict. Deg.	Ang. of frict. Min.
Oak on elm, fibres parallel to motion	·25	14	3
Wrought iron on brass ..	·17	9	39
Steel on cast iron	·20	11	19
Brass on cast iron	·22	12	25
Hard on soft limestone ..	·67	33	50

Referring again to **106**, the student who has any knowledge of trigonometry will see that the coefficient $\frac{8}{30}$, or $\frac{BC}{AC}$ is the tangent of the angle [illegible] tangents. The coefficient of friction may therefore be stated in different ways, all having the same meaning. In **106** it is equivalent to $\frac{\text{height}}{\text{base}}$ or $\frac{\text{friction}}{\text{normal pressure}}$ or $\frac{\text{resistance}}{\text{normal pressure}}$ or tan A. This ratio is frequently represented by the Greek letter μ. If, then, F = frictional resistance, and R = normal pressure, $\frac{F}{R} = \mu$, and $F = \mu R$; *i.e.*, if R be known and multiplied by the coefficient of friction obtained from a table, the amount of friction between the two bodies may be determined. It will be noted that in the first experiment the coefficient of friction was stated as the ratio between the friction and the *weight*, and that now *normal pressure* is substituted for this term. By the normal, or perpendicular, pressure of a body is meant the amount of pressure acting *perpendicularly* to the surface on which it rests, and though this would be synonymous with the weight in **105**, it would not be so in **106**. The perpendicular pressure of a locomotive on a level track would be equal to its weight, but on a gradient the pressure acting perpendicularly to the rails would be less than the weight, and would continue to grow less as the slope increased.

Laws of Friction. Less than 80 years ago General Morin, of the French Army, discovered, after investigations lasting two or three years, certain fundamental laws governing friction. Though more delicate apparatus and more extensive experiments have shown that the universal application of these laws fails, yet they are sufficiently correct for all but extreme cases.

1. Friction is independent of the extent of the surfaces in contact.

2. The amount of friction is proportional to the pressure between the two surfaces in contact.

3. Friction is independent of the velocity with which one body moves over the other.

For ordinary pressures and velocities these laws are generally true, but are not correct for high velocities and extreme pressures. As velocity increases, the coefficient actually decreases, and vice versâ. Experiments with lubricated journals have shown that as the speed of revolution slowed down from 18 ft. per second to a stop the coefficient of friction gradually increased. Temperature is also an important factor. Several other laws or conditions have also been deduced from experiments.

4. Statical friction, or the friction of rest, is greater than kinetic friction, the friction of motion. This was proved in the experiments in the preceding paragraphs, and is illustrated when a child slides its mother's flat-iron down the washing-board.

5. Statical friction is increased after the two surfaces have been in contact some little time.

6. Rolling friction is less than sliding friction.

7. In rolling friction the resistance is proportional to the weight, and inversely proportional to the radius of the wheel.

[illegible] in overcoming [illegible] , or electricity.

Friction of Liquids. The laws just stated for solids do not apply to liquids. Investigations have so far failed to discover a coefficient of friction such as that for dry surfaces. Apparently, frictional resistance is proportional to the area of the surface of contact. At low velocities resistance is small, and probably = speed × area of surface × a coefficient, but at and above a certain critical speed the formation of counter currents increases resistance, so that speed in the above equation has to be squared. The resistance is largely independent of the material composing the solid body with which it is in contact, and it is also independent of the pressure to which the fluid is subjected.

PRACTICAL APPLICATIONS

The applications of the foregoing may divide themselves naturally under two heads—that in which the endeavour is made to utilise friction, and that where the object sought is to reduce it as far as possible. Each, therefore, involves entirely opposite sets of conditions, and each has an immense number of applications in practice.

Brakes. Taking the first group named, we see friction utilised in brakes, in clutch connections, and in certain forms of gears for transmission of power. A common example of brake friction was illustrated in connection with the lever in the last article. The coefficient of friction, combined with the very large arc of contact between the brake strap and its band pulley is so high that such brakes are capable of sustaining weights as high as 8 to 10 tons by their friction alone. This is regularly utilised in cranes, in which the reversal of the crane movements is avoided by "lowering with the brake." That means, of course, not that the brake does the lowering, but that the weight of the load is the agent, and the brake regulates the rate of, and checks, the descent at the right instant. Thus, 107 shows a brake (A), a drum (B), and barrel wheel (C), all on the same shaft. The load is hoisted on B by the wheel C, actuated by a pinion, but it is lowered by *braking* on A. What this means in economy of time and labour may not be apparent on first thoughts. But imagine, in a hand crane, the slow and fatiguing movement of turning the winch handles and slow gears to lower a load. Or, in a power crane, consider the useless running and rattling of gears in engagement by comparison with the swift descent of the load by its own weight. The band-brake is used also in winding and hoisting machinery employed in mines for controlling the descent of cages and skips. In light mechanisms the same device is employed to bring rapidly rotating parts to rest in order to save time or to avoid danger. The most familiar is the cycle brake.

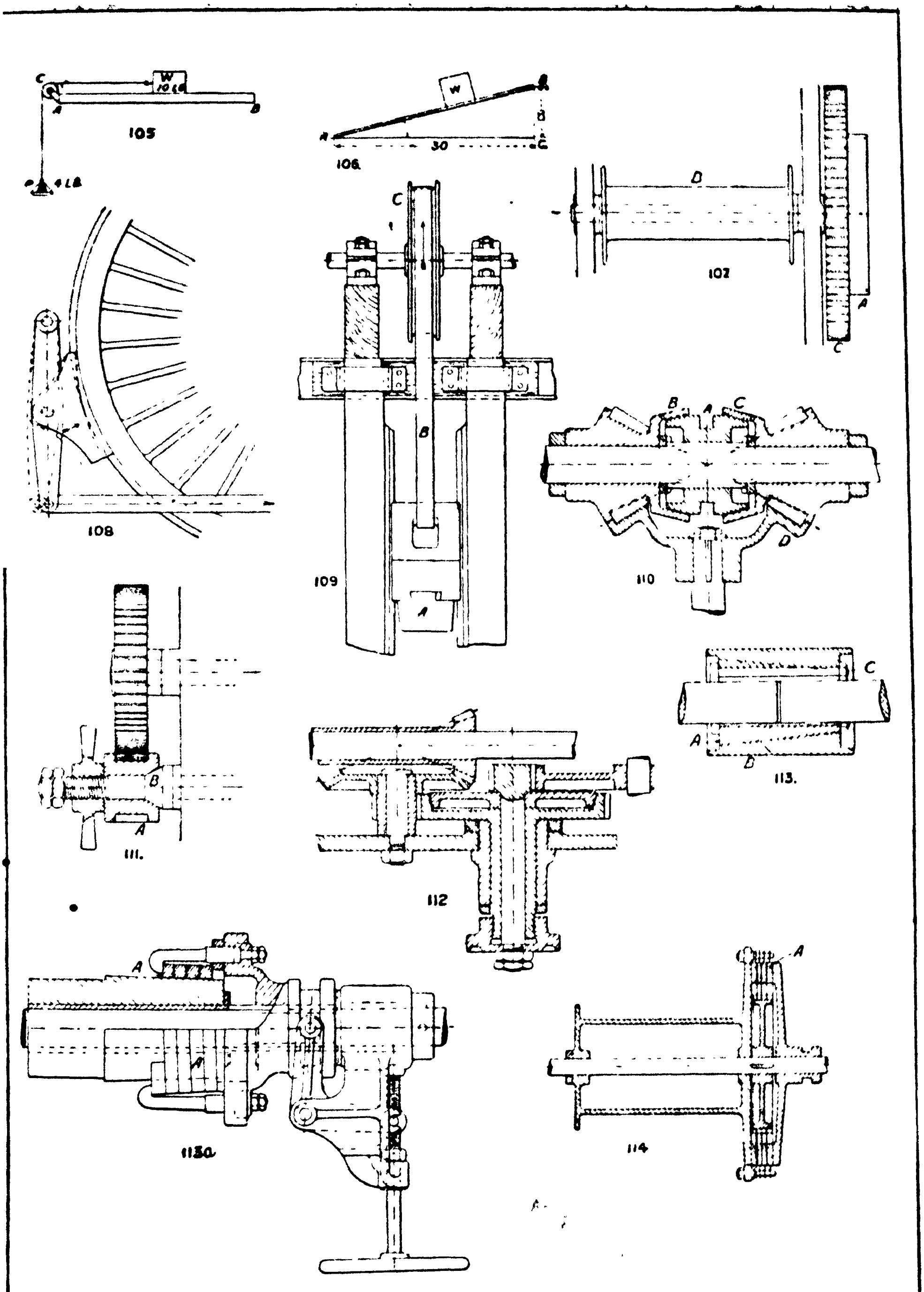
Brakes need not make large arcs of contact as the flexible bands do. There are many rigid slipper brakes used, operating on comparatively short lengths or arcs. When the turner presses his hands upon the driving pulley of his lathe to bring it rapidly to rest, his hand is applied as a friction brake. The big tramcars are arrested by slipper brakes pressing upon the rails. Railway trains are brought to rest by the pressure of wooden or metallic brake-blocks pressing on a small portion of the circumference of the wheels [108]. But there is enormous pressure behind them, produced by vacuum or steam-pressure agency.

Belt-hammers. Fig. 109 shows a friction device that may be seen in hundreds of smithies to-day—the drop hammer. Only the upper portion is illustrated, as with that alone we are concerned. The tup, or hammer head (A), which delivers the blows on forgings or dies, is lifted by the frictional contact of the leather belt (B), around the smooth iron pulley wheel (C), rotated constantly by shafting. The workman puts on the friction by pulling at the free end of the belt and letting it go when the tup has been sufficiently raised. As long as he keeps his hand on the belt, the latter makes contact round an arc of 180° with the revolving pulley, and the latter lifts the belt and its tup by friction. The illustration shows the tup at its full height. On releasing his hand the tup falls instantly, and so he adjusts the height for such blows as the work requires—light or heavy, slow or rapid—by simply and instinctively varying the pull of the hand and thence the friction of the belt.

Clutches. An immense group of friction mechanisms are the clutches, by means of which rapid connection and disconnection is made between moving parts of mechanism. A whole line of shop-shafting driving to numerous machines can be set rotating by the movement through a lever or hand wheel of a comparatively tiny clutch, making connection between it and the source of power, engine or electric motor. It can be instantly disconnected by throwing out the clutch. Friction alone is the agency by which the powerful engagement is made. The mechanism is of high value not only on account of its efficiency, but also because of its rapid character. Should an accident occur, it is not necessary to stop the engine, which takes some time, but simply to disconnect the clutch. In hoisting-machinery the same mechanism is frequently employed for throwing the different motions into and out of action. You do not stop the engine or electric motor, but throw the clutch in and out, so making and breaking connection with the various motions.

Further, the clutch arrangements are so designed that reversals of motion are effected without altering the direction of motion of the engines. The same design occurs over and over again in many groups of machines and machine tools. It comprises simply [110] a double-clutch (A), sliding and moved by means of a lever to right or left to engage with corresponding reverse clutches (B C), cast with bevel wheels, both of which engage with one crown wheel (D), so that the shaft rotating in one direction is made always to turn the crown wheel and its shaft in either one of two directions, according as the clutch is slid to right or left. These *cone clutches*, as they are termed, are used for both light and heavy machinery. Given sufficient frictional area, which is obtained by increasing the diameter and width, they are capable of sustaining the heaviest loads that are ever required to be operated.

Cone friction is also employed on many machine tools for the purpose of starting and maintaining movements of parts. It is in the form of the cone clutch (friction feed) [111 and 112]. No great effort is required on the part of the attendant, but the simple turning of a cross handle [111] or a knob [112] puts it in and out of engagement. In 111 the pinion (A), normally running loosely on its shaft (B) is tightened thereon by pressure against the coned neck, and then drives, or is driven, by the wheel with which it is in mesh. In 112 the cones are of large size, drawn in by the knob and screw to traverse a lathe carriage through spur and bevel gears and rack (not shown). Fig. 113 represents a cone coupling for shafts. It is often made with two reverse cones. The cone is tightened round the shaft ends by friction grip obtained by drawing the split cone (A) along its sleeve (B,) by the bolts (C), which are three in number. There is not much range in the useful angle for proper frictional grip in the foregoing figures. If too high an angle is given, slip will occur; if too low, seizing of the parts. In other words, the clutch surfaces will stick together so that they cannot be separated. The drawings are to scale from actual mechanisms. The surfaces in contact are turned to templet, to make a perfect fit. No lubricant must come between them. Iron and iron are generally used in contact. Steel is not satisfactory, being liable



EXAMPLES OF FRICTIONAL DEVICES

to seize, and as steel is often used for clutches, one is then properly lined with copper, which grips well with its fellow of steel without seizing.

Coil Clutches. A successful device for doing away with the rigidity of the common cone clutch is the coil clutch [118a] of the Consolidated Engineering Co., Ltd., of Slough. It substitutes an elastic frictional medium (the coil A), which, being forced endwise, contracts and grips the inner cone. The coning is very small in amount. It is instant in action, and requires little power to hold it in place. It amounts practically to a split cone, to which, however, it is preferable. No better proof of the efficiency of these can be given than the fact that they are in some cases used for transmitting as high as 1,500-horse power. Pressure is brought to bear on the coil by any convenient means, as by the hand wheel, screw, and levers in the illustration.

But a friction clutch need not be coned. It may have flat faces, as in the Weston clutch [114] and modifications of it. Here discs of hard wood (A) as originally used are pressed into close frictional contact over their entire surfaces, and the grip is enormous. At present discs of steel and bronze have been substituted for wood, as they are more durable

Sellers' Discs. Another form of friction drive used to a large extent for nearly twenty-five years past is the Sellers' discs [115]. Two discs (A A), having a slight capacity for adjustment towards and away from each other, embrace, or are released from contact with other discs (B and C) by a carefully graduated spring pressure acting on the globular boss seatings of A A. Motion is thus transmitted from the toothed gear adjacent, to B, through A A to C, by the simple frictional contact of the discs, and the lathe feed is thus actuated. This device, of course, also embodies provision, though not shown, for varying the rates of revolution between the driver (B), and the driven (C). A lever moves the centres of A A horizontally in relation to B and C, and thus produces engagement between the discs at varying radii, with consequent varying rates of relative speed, since the discs A A are capable of gripping B C at any radius. There is another common device—the bowl feed [116], in which a smooth-faced wheel (A) (the bowl) is driven by contact with the flat face of a disc (B) at varying rates. The variation is produced by altering the radius at which the bowl makes contact.

Expanding Clutches. In another common form of transmitting-mechanism the friction is that of plain cylindrical surfaces. As these cannot be slid into and out of engagement like the coned form, the inner ring (A) [117] is divided in the radial direction, to render it elastic (an expanding clutch), and a wedge (B) is used to force it open sufficiently to make frictional contact with the outer casing. The wedge is actuated by a key (C), thrust along by a cone (D), also an example of wedge friction. Clutches of this general type in various modifications are used in hoisting-machinery, and in capstan lathes for the rapid throwing in and out of the back gears.

Expanding clutch rings are operated in various ways, one successful type, Heywood & Bridge's, being shown in 118. The ring (A) in halves is thrust outwards to make frictional contact with the outer solid ring by sliding the clutch boss (B) on its shaft, and with it the toggle levers (C). The action is to turn screws of quick pitch on the pins (*a a*), which force the half rings outwards away from each other simultaneously. The hand wheel (D) is the means by which the movements are effected, but this is a variable element, which differs in the numerous applications of the essential clutch mechanisms.

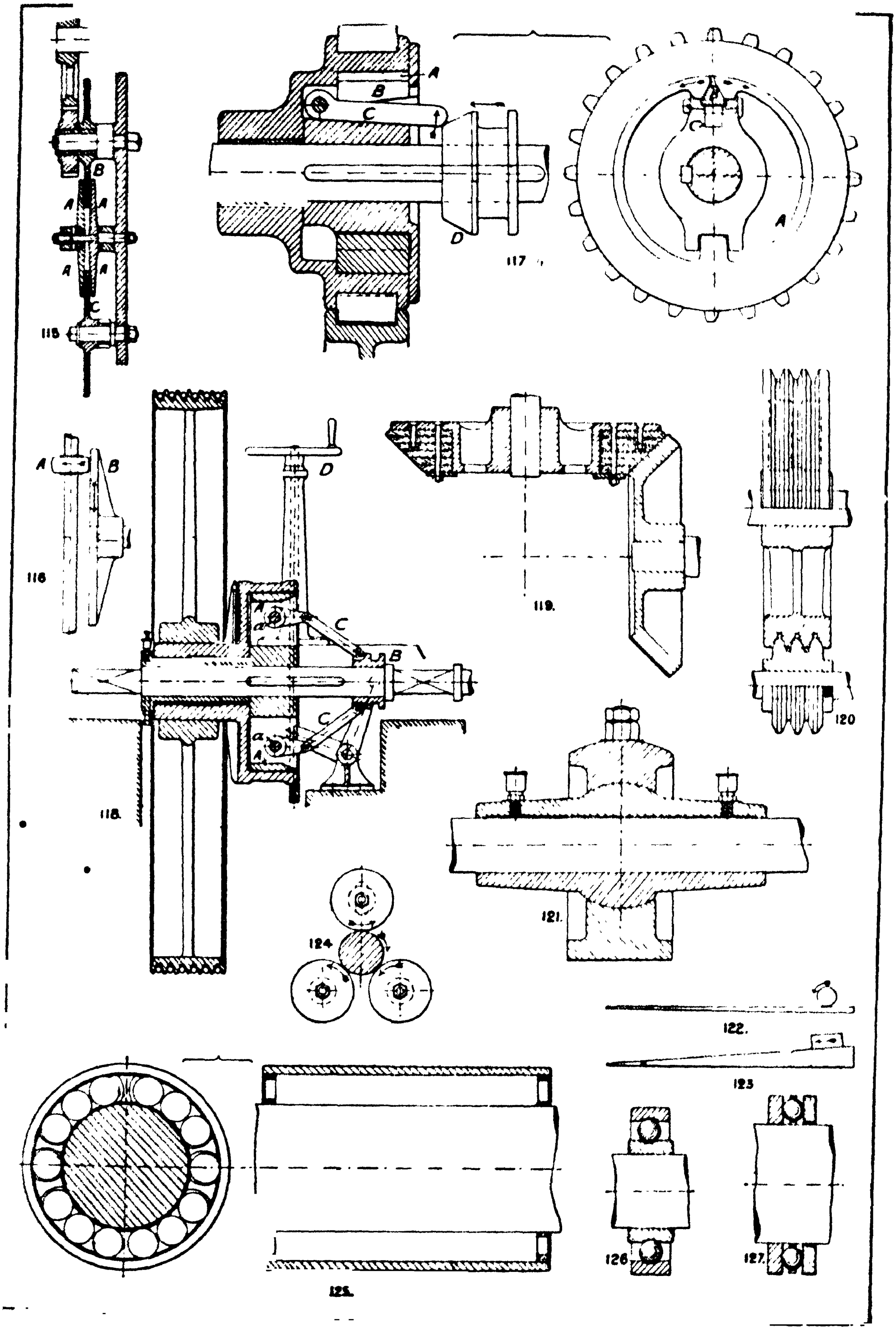
Friction Gears. A fair amount of gearing is made without teeth or cogs. Fig. 119 shows bevel wheels with smooth faces, and spur wheels are made similarly. They drive and are driven by frictional contact alone.

In another way friction is often utilised for the transmission of power, in the wedge gearing [120]. Wheels transmit power by interlocking truncated wedge sections instead of by spur teeth. The advantage is that of very smooth running. In other words the friction is all used for driving, and none is wasted, as in toothed gears. Instant connection and disconnection can be made. Unfortunately, this method of driving is not powerful enough for heavy loads, and its use is, therefore, restricted to light hoists.

Shafting Bearings. In the early part of this chapter the law was stated that friction was independent of the extent of surfaces in contact. Now, that fact is constantly receiving application in the bearings of shafting. Formerly shaft bearings were short, from one and a quarter to one and a half times their diameter, and much trouble arose in consequence, due to their rapid wear and seizing. Now their length is made from twice to three times the diameter or more [121], with resulting lessening of friction per unit area, and greatly enhanced durability. Moreover, the higher the speeds at which machinery is run, the greater is the advantage of increased bearing length for the shafting. This is seen, among other examples, in the shaft bearings of blowers and fans, of circular saws, of moulding cutters, and of grinding machines, where it is common to find bearings from three to four times longer than their diameters.

Lessening of weight on bearings, with the object of reducing the intensity of friction, is studied. Thus, shafting of steel is substituted for that of iron, because steel may be of smaller diameter and of equal strength and stiffness with iron. Pulleys are made of steel instead of cast iron with the same object.

Belting. The friction of driving belts is the important factor in their application. Belts slip if the resistance of their work overcomes their friction. To increase friction as much as possible is the reason why horizontal are preferred to vertical drives, why a long drive is better than a short one, and why pulleys are selected, when possible, not greatly dissimilar in size. It is a question of amount of arc of contact. A horizontal drive is better than a



EXAMPLES OF FRICTIONAL AND ANTI-FRICTION DEVICES vertical one, because the belt sags, and so lies better round its pulley on the driving side. In a vertical drive there is no sag. A long drive is better than a short one, because the sag is greater. Using pulleys reasonably alike in regard to size, the belt makes contact round, approximately, half the circumference, or 180° of arc, but with very large and very small pulleys it makes much less than 180° of arc round the small one, and the belt inevitably slips, an evil which is increased when the pulleys are nearer together, or with a vertical drive.

Out of this great fact of friction comes the important problem of the efficiency of machinery. We have mentioned that in some cases half, or more than half, the power put into mechanism is lost in friction. If a machine sustains such loss, its efficiency is only 50 per cent., and, technically, that is its modulus. This is generally ascertained by means of a brake dynamometer, in which the absorption is measured directly.

Rope Friction. The value of friction is seen in the coiling of a rope round a bar for the purpose of paying out or drawing in, applied in many laborious tasks The labourer employs it in lowering heavy wine and beer casks into underground cellars, the woodman in felling trees. A crowbar is driven firmly into the ground at a considerable angle to prevent the rope from slipping off in the vertical direction. If a cask is being lowered, the rope is payed out in easy stages, and directly the weight begins to overhaul, the rope is pulled round to make a larger amount of contact with the bar, and so the cask descends safely in a succession of stages.

In the work of tree-felling there comes a critical period when the tree approaches a state of unstable equilibrium. That happens when the wood has been chopped away on the side in the direction in which it is intended that the tree shall fall, and sawn nearly through on the side opposite. Then several men pull on the rope attached to the upper part of the tree at one end, and passed round a single sheave pulley at the other, firmly attached to a bar driven into the ground, and another man tightens the free end of the rope by coiling it once or twice round a bar, also driven into the ground. The tree bends, but is still so rigid that it would overcome the strength of the men unless the rope were made fast. The woodman plies the axe again and the men pull, another coil is made, and so on until the tree is bent over sufficiently to bring its trunk well outside its centre of gravity, when its weight ruptures the remaining fibres, and it falls with a crash.

In another way rope friction is utilised, in the warping-cones on wharves and dock sides and on shipboard. The coil of a rope twice or thrice round the body of a capstan is sufficient to bring the biggest vessels to rest, or to regulate their casting off from their moorings into the stream.

Rolling Friction. We now look briefly at the other aspect of friction, that in which the endeavour is made to get rid of it as an undesirable thing. With regard to the two kinds of friction, that of sliding, which has been discussed, and rolling, the distinction is a most vital one. Imagine for a moment what would happen if a brake strap and its wheels were thoroughly greased or oiled with such a sensible thickness of lubricant that the brake and wheel could not come into actual contact. Each particle of grease or oil would be a tiny globule rolling between the surface and preventing contact. Substitute for oil an infinite number of minute steel balls—the effect would be the same, to prevent the surfaces from gripping at all. That would be rolling friction, substituted for the sliding friction of the band and wheel. Hence, if two surfaces can be separated by a rolling object, the friction which absorbs power is nearly eliminated. The ball and roller bearings, now so common, embody rolling friction, and are, therefore, to a great extent, frictionless. Just in proportion as point or line contact in these is substituted for surface contact in the other class of mechanism is the frictionless ideal realised. Here difficulties of manufacturing come in, and also the difficulty of permanence, because in proportion as wear develops does the ideal become defeated. These things will be found treated under MACHINE DESIGN, but it is necessary to draw attention to them here.

The difference between rolling and sliding friction is illustrated in **122** and **123**. A ball or roller will run down a slope of 1 in 200 [**122**], but a block of polished metal [**123**], will require an angle of 1 in 14 at least to slide down.

Fig. **124** shows a common device in which the axle of a treadle lathe runs between three anti-friction rollers with great ease of movement. Fig. **125** is a roller bearing, and **126**, **127** ball bearings of two types, **126** being for a revolving shaft, the equivalent of a journal, and **127** being one to take up end thrust.

Continued

Continued from page 771

PRIZES WAITING FOR INVENTORS

Problems for Men of Imagination. The Defect of the Sewing Machine. Plagues to Conquer. Rewards for Engineers, Architects, Chemists, and Electricians

By ERNEST A. BRYANT

THE records of the Patent Office of this country, like those of America, show that talent often goes unrewarded in our own day, as it did in times which are gone. Between abstract science and invention there is this difference: that in the former, one man's discovery may at once be turned to the advantage of the whole community; in invention, a sound idea may lie dormant for years. Its originator, perchance, has patented it, but has not the means himself to develop it, and cannot find the man with capital necessary to finance him. This unfortunate condition has a two-edged effect: it prevents the original inventor from reaping his harvest, and it acts as a barrier in the way of another man who has a somewhat similar scheme, with which he would be able successfully to proceed had not the hopeless man, who has anticipated him at the Patent Office, first registered some of the ideas vital to the whole project.

Handicapping Industry. How serious may be the effects of a position such as this was shown by the experience of Lord Armstrong, the founder of the great Elswick works. He, with Brunel, prepared to give effect to a plan for the coiling of wire about the inner barrel of his heavy guns. It was one of his earliest ideas, but one which he had permitted to remain in abeyance what time more pressing schemes were carried through. When, however, he came to develop this idea which had lain so long in his brain, he found that the discovery had already been patented. This was a very serious set-back. •The patentees were unable successfully to carry out the idea which they had registered; it was of no use to them, but it stopped the progress of Armstrong along that path. All that he could do was to lay aside his idea for the years which the patent still had to run. Then he was free to give effect to his project, and highly important results were in consequence attained.

The pity is that invention and industry may be hampered in this manner. Many a valuable idea has been permitted to escape by men who could not afford the risk of litigation which its patenting might involve, or who would not face the worry and annoyance incidental to such dispute. The crank, by getting his wild ideas set out at the Patent Office, may bar out the practical man. It is a fortunate circumstance that this vexatious procedure has not a wider application, or we should to-day be restricted to one form of telephone; to one system of wireless telegraphy, and be told—as was a pioneer in electric telegraphy, when the semaphore was the sole method of communication—that there is no further need of development in these directions.

Undirected Genius Runs to Waste Another aspect of the case, which will appeal more to the young man of inventive mind, is the lack of proper direction for genius. Men of undoubted creative ability fritter away their lives on fanciful schemes, believing their poor geese to be all resplendent swans. Those same men, guided aright, might produce work of real value to the community. How many men of skill have wasted hours and money trifling with machinery which they feel certain will solve the problem of perpetual motion! Wonderfully ingenious are some of their contrivances, and often capable of extension in directions quite different from those which their creators contemplated. But, from the machine for perpetual motion, as such, no man is a penny the richer nor one whit the happier. Applied to serious service the talents thus wasted might add to the common stock of useful inventions.

We have already considered a number of ideas to which potential inventors might profitably apply themselves. Obvious needs, like obvious opportunities, are mostly overlooked. The commonplace invention has no attraction for the man of mechanical ingenuity. Yet, as has been shown, some of the simplest devices are those which yield fortunes to their makers, and greatest advantage to those to whom they are sold. Sewing machines were not perfected in the day of Hood, or the "Song of the Shirt" might never have been written. Many years, however, have elapsed since they attained to what we are now bidden to regard as approximate perfection. Yet the poorest, most unimaginative seamstress could point out a glaring defect which apparently has escaped the notice of successive generations of inventors.

What the Sewing Machine Lacks. The great defect of the hand-machine, and, in a lesser degree, of the machine worked by the treadle, is that the spool contains an insufficiency of cotton. Repeatedly the worker has to cease stitching, remove her work, take out the spool and refill it with thread. For the upper part of the stitch, the needle is fed from a reel upon which may be two or three hundreds of yards. What the seamstress needs is a like accommodation from the spool. Either this latter should be larger, or it should be possible to slip in a reel of thread below the place at present occupied by the spool and shuttle, and work directly from that. The sewing machine can at present be made to do practically every stitch possible in hand-sewing; can work elaborate patterns, floral designs, and what not, but so far the question of an adequate supply of cotton for the spool has been beyond the capacity of the inventor. The camera fitted with films gives the idea for this matter of cotton for the sewing machine—and of ribbon for the typewriter. When all the films on a sheet have been exposed, the lot is wound up and taken out, and a new roll substituted. The same scheme should be practicable with a reel of cotton or a spool of inked ribbon.

An Enemy of Mankind. Given a definite objective, men with ability to conquer difficulties will work. Such gigantic problems as the cure of consumption, cancer, and leprosy, engage the minds of many of the greatest men of the age. One by one, fevers and kindred ills are rendered subject to their skill. But there are lesser problems for solution by lesser men. While the present course was in preparation — in 1905 — the savants of Paris sounded a warning against that filthy pest —the common fly.

This insect, it has long been known, carries corruption and disease wherever it goes. To the many counts in the indictment against the fly is added the charge of disseminating cholera, by whose ravages Europe, in 1905, was again alarmed. The horrors perpetrated by the fly cannot be commonly known, or the pest would not be tolerated year after year in every home in the land, in every place where food for human beings is kept. Nor can it be known what a foe to the sick the fly can prove.

It has been demonstrated that the common blowfly will deposit its grubs in the mouth or nostril of a prostrate invalid; that those grubs will eat their way into the brain of their victim, and drive him or her mad. If there were a plague of flies in China or Tibet, we should send out funds for their extinction, but, because they swarm in our midst, we regard them as a matter of course. Perhaps it may be an incentive to ingenious sanitarians if they be reminded that a Paris newspaper—the "Matin"—has offered a prize of £400 to the discoverer of the best method of destroying this dangerous parasite.

Commercial Possibilities of the Rat. Another plague by which we are more or less scourged is the rat. Its depredations represent a vast sum each year to merchants and dock companies, to say nothing of less considered operations in the shops and warehouses of our large towns. Moreover, like the fly, it has been proved to carry disease; it carried bubonic plague to Glasgow. Rats have been known to gnaw the corpses of persons who have died from infectious disease, and then to escape in freedom to spread corruption. Also, they have been found to cause the death of children, biting their flesh as the little ones slept, until they pierced an artery. The rat has apologists only in those who regard him as a useful scavenger. But our sanitary authorities are not so inefficient as to need the assistance of these vermin. Perhaps, if the commercial possibilities of the rat were recognised, there might be greater hope of his numbers being diminished.

The attempt was recently made to popularise the use of moleskin as a fur for ladies. Now, the mole is useful in the extreme to the farmer, who, although compelled occasionally in self-defence to thin out the numbers of his subterranean ally, could not wholly dispense with his services. The skin of the rat has decidedly a market value. Buckland mentions the importation of ratskins from France for glove-making, but adds that his information was that the skins were too delicate except for the finest wear. On the other hand, he mentions slippers made from ratskins which were handsome, durable, and comfortable. The pelt of a grain-fed rat should make as good a covering for feet and hands as many other mysterious materials now sold as kid. There is no waste in the modern manufactory, and the maker of gloves would be hard set for ideas if he could not turn the hide of the rat to good account. Ratskin by another name would be well enough, just as dog-fish sold in the shops of the poorer neighbourhoods has a vogue under another denomination. In some parts of the world, by the way, the rat is a food-staple. It is not popular as diet here. Neither, for that matter, is the snail, although South Down mutton owes its peculiar richness and nutritive qualities to the number of tiny snails eaten by the sheep with the grass in which these small molluscs in myriads make their home.

A King's Prizes. These are not schemes seriously to engage the time of many, though the man who can rid us of such plagues as the disease-spreading flies and rats will deserve well of his fellows. More important to those for whom this section of the Self-Educator is designed are such measures as are contemplated in connection with the Milan Exhibition of 1906. The King of Italy himself offers £1,600 in prizes to exhibitors who comply with the conditions which he lays down.

The first prize consists of £200 for the best automatic safety couplings for railway rolling-stock. This is a phase of work which has long baffled the railway engineer. For many years past railway servants have been agitating for the introduction of such appliances as shall enable them to carry on shunting operations with less risk to life and limb than is now inevitable. Careful as are our great companies, the list of casualties each year among the many engaged in handling freight traffic at the great depots is grievously heavy. The man who can invent the required apparatus will not only realise a fortune; he will be canonised by the men to whom, by his invention, he ensures longer life and relative immunity from accident.

A sum of £200 is offered for the best method of testing high-voltage electric currents without danger to the operator. Investigations in this field may reveal secrets not yet learned by the electrician. The specific want expressed by the King of Italy is sufficiently serious to warrant the investigation necessary. Perhaps the man who discovers the safe and certain way of testing high-voltage currents may also be able to point the way automatically to "deaden" a live wire fallen from its place. With the increase of electric trams in this country, the live wire becomes more and more a peril in everyday life. Our accident list is happily less heavy than that which America has yearly to mourn. It ought not to happen that if a live wire fall, a human being or animal coming in contact with it must almost inevitably be electrocuted.

A Better House to Live in. The two largest prizes offered by the King of Italy are of £400 each—one for the best and most original exhibit of machinery or manufacturing process, a competition of boundless horizon; the other is for the best type of popular dwelling adapted to the climate of Northern Italy. This latter appeals, of course, more specially to the Italian architect. It is suggestive, none the less, of an interest in the affairs of the people which might with advantage be copied in other parts of Europe. The housing problem must be faced sooner or later in this country; perhaps the example of the King of Italy may inspire our Local Government Board to similar enterprise.

It is paying British architects too poor a compliment to imagine that the wretched hovels of our present-day mean streets are the best that they can furnish. Of equal domestic interest is the £200 prize competition for the best established method of distributing healthy and pure milk in centres of population. In England it would seem as if punishment of detected offence—not prevention—is to be solely relied upon. What the individual consumer wants is a cheap instrument which will tell him the composition of the milk sold to him as pure. If the poor housewife were able to detect the presence of added water and boracic acid in the milk for which she pays her hard-earned pence, there would be less deleterious fluid given to add to the inherent weakness of infants.

Navigation of the Future. Motor-boats are the subject of a £200 prize. In this direction England has given the lead to the rest of Europe. But the industry is as yet in its earliest infancy. A turbine steamer made the passage from Dover to Calais in 1905 in fifty-one minutes; when the manufacture of motor-boats is taken seriously in hand by the shipbuilder we may get stout, dependable boats which will carry us across in half an hour. For inland navigation, as well as for sea-going, there is a great future for mechanically driven craft. If our canals are to be developed as they should be, the old horsed barge will have to give way to faster carriers. It would not even now be impossible to build the kind of craft capable of carrying the requisite load at the speed desired. An important consideration, however, is the "wash" caused by such craft. There may be more of fancy than reality in the objections raised. Scotland, when she saw her first steamer, was afraid that all the banks of her inland waterways would be damaged beyond repair by the new-comer. Still Scotland stands where she did.

Telephones at a Penny a Week. One point of interest to inventors is omitted from the Milan Exhibition's prospectus of prizes. The king's list does not include telegraphy or telephony. British inventors, remembering that Mr. Graham Bell, one of the earliest pioneers in telephony, is their countryman, have still to hasten with all their energies if they are to maintain a place in the race for patronage in regard to this science. We want instruments which will record messages without the subscribers being present personally to receive them—messages which can be repeated at will. American inventors are working towards the perfecting of such a machine. They promise, too, so to cheapen the whole process that before long companies will be able profitably to operate the telephone at a cost of only five shillings a year to each subscriber. England will, of course, gain from any new inventions in the United States—by paying for them. It is full time, however, that electricians in this country made their names heard again in this vast, profitable, and fascinatingly interesting field. The late Postmaster-General declared that practically the limit has already been reached in long-distance telephoning. The inventor is under obligation to remove that disability.

A New Kind of Paper. Another industry to which the Milan Exhibition may give a stimulus is paper-making. For a certain class of paper, Italy is our only rival. This make has been called forth by special circumstances. Climatic conditions necessitate special measures in regard to the burial of the dead, and they have had to fashion a paper specially for post mortem wrappings. The paper for which British manufacturers are seeking, and seem at last on the way to find, is one of a somewhat similar character. The "life" of good paper in a library book is very long. The same paper placed underground is much shorter. The fermenting substances in the earth destroy it.

Vast quantities of paper are required by Government and by private firms for electric installations underground. It is an excellent non-conductor of electricity so long as it remains dry. When it becomes moist, however, its value as a non-conductor vanishes. What manufacturers are seeking, therefore, is a paper which will resist damp as resolutely as does indiarubber. A secret process is already under trial, but success is not yet announced. The industrial possibilities of such paper are not exhausted by its application to electric cables; shopkeepers need a good cheap paper of this description. The fishmongers would be glad to do away with the basket if they had the chance. They are awaiting the advent of the moisture-proof paper.

Continued

SALAR JUNG LIBRARY

Group 9

DRESS

7

Continued from page 864

EVENING DRESS

Yokes and Kilted Frills. Evening Gowns and Cloaks. Some Hints about Unlined Skirts. Paper Patterns

By AZÉLINE LEWIS

At the present moment transparent insertions and fancy designs of lace, embroidery, and medallions of fine tucking inserted with faggoting, are the leading features of dressmaking, particularly in the dainty and beautiful varieties of the ubiquitous blouse. All these require good work, much care, and deftness not to stretch the material, and in neatening the edges that are cut away beneath the inserted portion.

If the design is curved or intricate, or anything is inserted separately, and the material a thin or flimsy one, tack it in position, sew carefully all round the edges, and cut away the material on the wrong side, following the shape of the insertion, and neaten round the edges.

Fancy Yokes. For these, lace, narrow ribbon, velvet, or crossway folds may be arranged in any design and united by faggoting, or variations of this. If crossway strips be used, these should be from a ¼ to ⅜ in. wide when made up, for which it will be necessary to cut the material ¾ in. or more in width, to allow for good turnings. Join carefully, open and press seams, snip selvedges, and fold down the edges on each side; then put the two turned-in edges to face, and tack closely on the right side—be careful it does not get twisted—then tack in the position required before working.

As to fancy neck-bands and cuffs, the variety of these is infinite; and plain and tucked silk, net, lace, or chiffon, strips of lace, ribbon, or crossway folds, united by faggot stitching, and many other things enter into their composition. Some of the collars are quite straight, others like our drafting, this being a matter of taste. For such a neck-band, the edges and ends need only be hemmed, and the fastenings may be either silk loops and tiny buttons or hooks and loops, both being, of course, quite small. If stiffenings are needed, they should be narrow silk-covered bones of the depth of the collar, one for the back, and one on each side. For a transparent collar, a lining of chiffon is a great improvement.

The cuffs must be made to the shape of the lower part of the sleeve. If required to fit closely, the opening should be only just long enough to allow the hand to slip through, and be neatened by a hem or narrow bind of the material, so as to show as little as possible.

If stiff cuffs, collars, and revers be required, these must be made upon leno, stiff muslin, or canvas, and arranged on this in the same way as the skirt facing, unless the edge be corded. If the inside is likely to show, the cuff must be faced with silk or sarcenet.

Kilted and Box-Pleated Frills. Kilted, or knife-pleated frills, are now generally done by machine, but if they are to be worked by hand, the top edge of the strip should be turned in, each pleat being small, and touching the last one. Tack the pleats down, being careful to keep them quite straight and to the folds, and then press on the wrong side.

For a box-pleat, make a fold to right and left of the required width, this varying, of course, with the material and depth of flounce. For the double variety, two pleats are made, one over the other, to right and left, which shonld be tacked down carefully. If deep, and the material is rather stiff, several rows of tacking may be required to keep them in position; then press on the wrong side.

Ruchings are made in the same way as box-pleatings, and either single, double, or treble, according to the material and purpose for which they are required. The sewing, however, is done in the middle, and not at the top, as in box-pleatings, and no pressing is required. For chiffon, or soft materials, the pleating should be as close and full as possible.

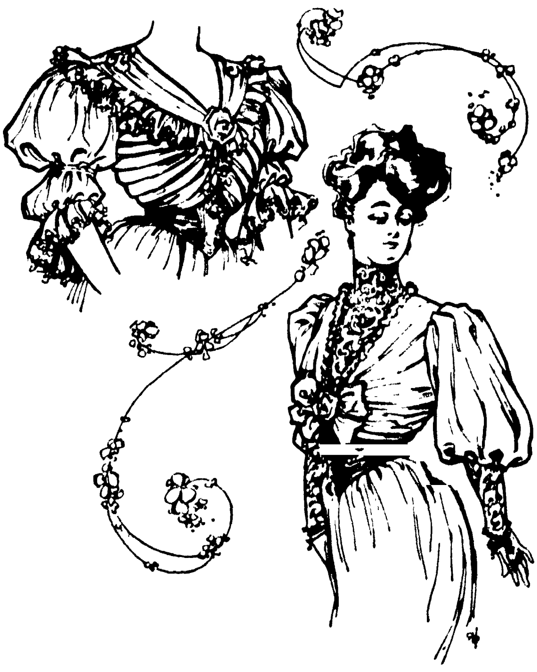
Evening Gowns. Fashion changes so frequently as regards evening gowns, that it is not possible to do more than give the worker a few broad hints. For the styles she will be able to study the various fashion papers. Dresses of a light and delicate nature should never be attempted till the worker is an adept at the machine, and is able to make all kinds of crossway trimmings, pipings, folds, frills, ruchings, flounces, run-on ribbons, insertion, lace; and put on all these things without injuring the fresh look of the material. The delicate fabrics employed for evening and smart summer wear want a light, quick, and sure manipulation to maintain the dainty freshness which should be their first charm. All dresses of a light and delicate texture should be finished as quickly as possible, and very great care should be taken to see they do not get soiled.

A washing overall should be worn, or a long apron and washing sleeves, whilst the hands should be kept scrupulously clean, and as cool as possible. To see that the machine is perfectly clean, try it on a strip of material before touching the garment, so that no unexpected spot of oil or dirt shall get to the needle, and so on to the fabric. Be very careful with the iron and the ironing-board and blanket, and spread a cloth or sheet on the floor when working upon or trying on the skirt. One or two of the latter should form part of a dressmaker's outfit.

Tack strips of muslin to the skirt edge as soon as finished, and also to any other corners and edges as soon as possible after finishing, and anywhere else that is likely to catch and get soiled. If the material, however, be soft and crushable this cannot be done, or, at any rate, it will require much care. But it should be remembered that all frills and ruchings and ornamentations of this kind should not be put on till as near the finish as possible.

A Draped Bodice. The two sketches in diagram 77 give two simple but very becoming arrangements of a draped bodice, the first for day wear, and the second a variation of the same model which effectively transforms it into an evening affair. The day bodice is of fine cloth or cashmere, or any other thin and supple material, with a yoke and under-sleeves of lace; whilst for the dainty evening bodice chiffon, crêpe de Chine or organdie can be selected for its expression, the neck being finished off with a folded fichu, the frill of which is edged with a ruching of chiffon. With the first a pointed rucked belt of silk is worn, and for the second the gathered belt is arranged in a flat-pointed stomacher piece of stitched silk.

For either bodice, the lining is made and fitted separately, according to the directions already given for bodice-making, except that the fronts only are faced with 2 in. of material on each side before the fastenings are put on, these being usually of the edge-to-edge kind.



77. A DRAPED BODICE

The shoulder and under-arm seams are left open till the right front drapery is arranged, which for this style is better pinned on one front, either on the stand or on the wearer, before cutting closely, when the second one can be cut exactly the same. From shoulder and front armhole it should be drawn somewhat tightly, but under the arm to the bust the folds may be a little looser.

The yoke is arranged and sewn on the fronts—and the back also if wished—then the material fronts are gathered under the arms, also a little where the sleeve is inserted, and secured to the corresponding portions of lining. The front edges are gathered and drawn together in the centre of the bust. The right side is caught to the lining, but the left is loose, as the vest fastens under it. The neck-band is transparent and lined with chiffon. It fastens at the back and has the bones arranged as described for fancy collars. The edges of the draped portion are turned in and hemmed, or just caught raw-edged to the material.

The back may be cut a little larger than the lining, and gathered or pleated slightly at the centre of the back, or it may be made the same as the front, but if so, this must be very carefully done to avoid a round-shouldered effect.

If preferred, a plain "stretched back" can be made. This should be cut on the cross, the fold tacked down the centre of the back, taking care not to stretch the material; then smoothed out well towards the shoulders, across the back, neck, shoulders, and under the arms. Be very careful to get this without a wrinkle. Pin and tack in position, then tack shoulders and under-arm seams together and machine-stitch.

For the evening bodice the foundation should be of silk, though fine mercerised sateen looks very well and is much less expensive. This is cut V-shaped at the neck, and is neatened with binding, when the material is arranged and the back and fronts sewn together.

The sleeves in this case may be of silk or chiffon, the latter, if transparent ones be desired. They are cut in the same way as the others, only the puffs are much deeper and fuller, then gathered three times across the lower part to form a second puff, which must be sewn to the chiffon or foundation.

The frills may be accordion-pleated, edged with ruching, which can be bought by the yard, or can be made by the worker, who must allow plenty for fulness. The "chou" bow which finishes off the front consists of a double crossway piece of chiffon, rolled loosely round and round from the centre like a rose, from which depend ends of narrow ribbon velvet, finished off with little rose-buds of the chiffon arranged in the same way.

In such a bodice lightness and quickness are of greater importance than very fine work.

The bodice lining, as may be easily seen, could be cut round or square as desired. A narrow china ribbon should always be run through the neatening at the neck to draw it up, unless a tucker be sewn in, when it is not necessary.

An Evening Cloak. We have selected the evening cloak in diagram 78 because it is one of the latest shapes and is very simple to make, but, at the same time, is capable of being fashioned into a very smart affair, according to the materials and trimmings employed.

In our sketch it is composed of fine, faced cloth, lined with soft quilted silk or satin, the trimming consisting of wide embroidered insertion, or jewelled embroidery, edged with ruchings of chiffon, two handsome ornaments being arranged at each side of the neck.

From diagram 79 it will be seen that it is another variation of the circular shape, and the worker should now be able to draft it with the aid of the measures given, or from the bodice pattern, allowing 4 to 6 inches extra to the chest measurement.

To cut the pattern out of 52-in. cloth without joins, 5¾ yards are required, though there is very little difference in the quantity if pieces be joined on. In faced cloth, each piece must be the right way up of the material.

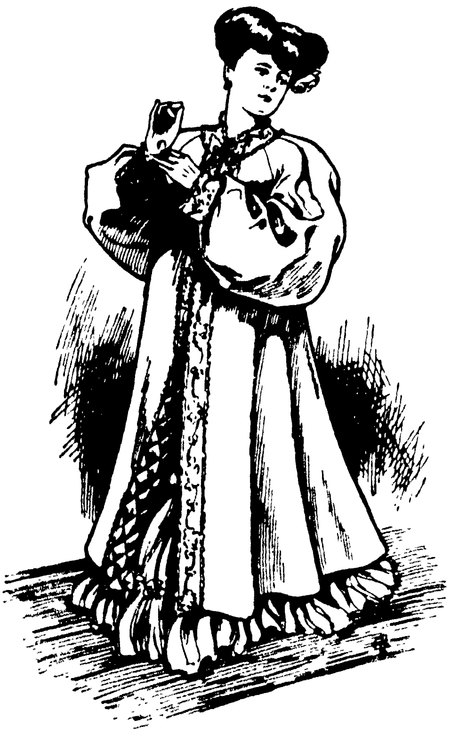
Mark round, and allow ample turnings when cutting out; tack up centre-back, also underarm seams, as shown by the notch; then machine, open and press carefully, first removing the tackings as explained for bodice. Turn in the front edges to the fitting-line over a strip of muslin, also lower edges, and tack down. Tack a piece of muslin to neck and armholes, to prevent these getting stretched whilst tacking the lining in position. This is more easily done *before* the sleeves are put in, as the cloak can be spread out flat. The lining may be bought ready quilted or done by the worker, as preferred. If the latter, join the silk, snip the selvedges, open and press the seams; then open out the wadding, tack the fluffy side to the wrong side of silk, and stitch. If not quilted, the cloak may be interlined with domet.

When the lining is tacked and felled in position at the seams, arrange, tack down, and press the box-pleat in the centre of sleeve; tack and seam up as directed for bodice. Pin and tack sleeve in the armhole, as indicated by the notches at back and front, *easing* it well, and then fit on the cloak to see that the pleat is quite right on the shoulder. If correct, stitch the sleeve in position, cutting away the muslin which was put to prevent its stretching, and press lightly. Pleat, and make the lining exactly the same, tack in position, and then fell the edges to cover seams of shoulder and armhole.

Turn in neck-edge over a crossway strip of muslin, and fell the cloak lining over the turnings; or the edge may be neatened with a piping. Secure hooks and eyes—if wished—to right and left sides, then turn in and fell the quilting to the cloak edges, being careful to pull away the wadding from the edge, to prevent any undue thickness here.

Now make the cuffs, gather and secure the sleeves between the upper edge of these, when the trimming can be sewn on round neck, down the fronts, and round the cuffs. If a stole of silk or material is required, this must be cut from the pattern, as shown by the broken line.

A little pocket on the inner left side, felled to the lining, with a piece of elastic at the top, will be found a great improvement, and can of course be made very pretty, if wished, by being pleated or trimmed with ruching. This, however, as well as the question of the further embellishment of the cloak, must be left to the taste of the worker.


78. AN EVENING CLOAK

Unlined Skirts. Unlined skirts of thin material may be merely hemmed up and not faced, when the edge should be protected with a roll, or "rouleau," of the material sewn just inside the edge of the skirt. This is a much prettier protective finish than braid or binding. An inside frill is also a desirable addition to such a skirt. This frill may be gathered or kilted, sewn on the foundation foot part, or merely to the edge; but with very smart gowns, one, two, or three frills may be employed when there is no question of cost.

Selvedges must be either cut off or snipped, or there will be a puckered effect at the seam. When sewing on plain, narrow velvet, hold it lightly, and just tightly enough to keep the outline, but not to drag or pucker the material. Sew it on with fine silk, making short stitches on the right side and long ones on the inside, so that the stitches will not show.

Folded or swathed belts should invariably be cut on the cross; this should be carefully borne in mind, or the effect of any dress is quite spoilt.

Joins must be carefully attended to, and placed so that they are not seen. If in the sleeves, the join should come in the under part; if in a bodice or blouse, it may be arranged under the arm, but nowhere else unless it can be hidden by trimming. On a skirt, all joins or additions must be at the bottom—at the back part of the gores if to the width, at the foot part if for the length—when the join can be concealed by trimming. It should also be remembered that all pieces added should be cut the same way of the material.

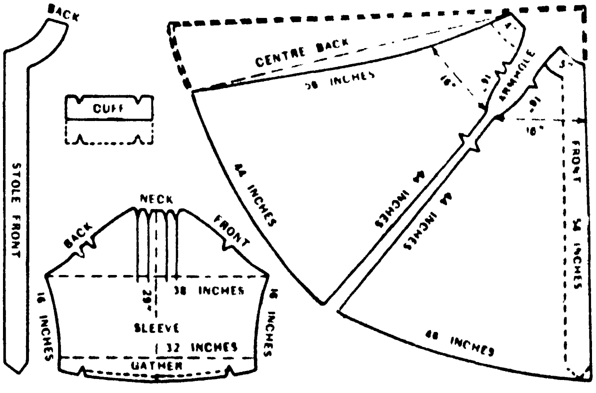
In spite of the advent of the machine, it may be pointed out that handwork still more than holds its own in the higher branches of dressmaking, and even tailoring.

Pressing should generally be done on the wrong side; but if it has to be done on the right, a cloth should be first placed over the material to protect it. Light-coloured fabrics should always be tested beforehand to see if they will stand the heat of the iron; in some cases it will quite change the colour if too warm.

Empire gowns are dealt with in "Underclothing." [See TEA-GOWNS.]

The making of a Princess gown is described in TAILORING.

Paper Patterns. We have gone somewhat fully into the matter of drafting and cutting various patterns, because it is well for the worker to understand this method. At the same time it is quite possible to produce excellent results without this knowledge, and by the aid of good paper patterns.



79. PATTERN OF EVENING CLOAK

But these require management, and any attendant failure should not be laid so much to their charge as to their manipulation and the wearer, whose measurements may deviate somewhat from the correct proportions upon which "stock size" patterns are built.

For instance, a figure whose general measurements may correspond with a 36-in. bust may have a narrower back or a longer arm than the pattern; a tall figure may be shorter, a stout one taller, than the average of their "build."

In taking these measurements, the tape should be placed over the fullest portion of the body.

In measuring for a skirt, for instance, let the starting-point be the hips, 6 in. at least below the waist, because this may be smaller or larger in proportion to the measure, and it is easier to take in and widen the skirt at the waist than to alter the hip part.

The outline should not be interfered with. If only an inch or so too short, lengthen at the bottom, but if several inches be required, insert a piece at the knee-line all round, by which the outline at top and bottom is not interfered with.

In the same way, the skirt may be shortened by making a tuck on each gore at the same place.

For a short, stout woman, pin the pattern round the hips, allowing it to drop in front till this hangs perfectly straight; be careful to get the back right and quite even before fitting the darts and seams from hip-line to waist. Pass the tape round this, pin in place, and mark carefully before cutting off any overplus or uneven parts at the top edge.

With respect to bodice patterns, the same rule as to getting the measure of the fullest portion will nearly always hold good. Some systems vary, however, so it will be well to ascertain the necessary measures before sending for any pattern.

One rule may be given: Get acquainted with each piece of a paper pattern, and study the relation of the various portions to each other before putting together and cutting out the cloth. Also study the notches, and put those together which correspond, as these show where each piece belongs—thus, 1 notch to 1 notch; 2 notches to 2 others, and so on.

The Dressmaker. Though so many have taken up dressmaking of late, there yet seems, unlike so many careers, plenty of room for good workers, who may be pretty sure of always being able to command a market.

But the work is hard and the hours long—whether the worker set up for herself, or whether she work for another. It must be remembered that in dressmaking—as in most things—though theory counts for much, practice alone will make perfect, and no one should think of starting for herself without the knowledge thus gained.

If the worker is desirous of perfecting herself in the higher branches of dressmaking, it may be well to enter some good firm as an improver or assistant. Apprentices in the best houses may have to pay a premium of £60 to £100 in the house, but if living or boarding out, £30 is the average fee.

In dressmaking, specialising prevails more or less in large houses, and good skirt and bodice hands are nearly always in request. Sleeve hands, too, are pretty sure of work.

Fitting is always a separate branch, and as it is the most difficult, is the highest paid in the trade.

Dressmaking concluded

Group 15
HISTORY
7

Continued from page 775

REIGN OF ALEXANDER THE GREAT

Accession and Conquests of a Marvellous Reign. The Great Greek Philosophers: Socrates, Plato, and Aristotle. Closing Days of Greece

By JUSTIN McCARTHY

Alexander's Accession. On Philip's death Alexander came to the throne of Macedonia and its conquered states. Alexander was then in his twenty-first year. His education had been remarkable and exceptional in every sense. When a boy and youth he had had for his preceptor the illustrious philosopher Aristotle. He was under Aristotle's teaching for some three years, but his father had little intention of encouraging his son to devote himself to philosophical studies, and was determined that he should begin as soon as possible the work of political and military government. He was but sixteen years old when his father, who was undertaking one of his foreign conquests, appointed him regent of the kingdom, and Alexander was understood to have shown much judgment, foresight, and statesmanlike firmness in his management of affairs. We have already told the brilliant part he played at the Battle of Chæronea. He had no sooner come to the throne than he found himself compelled to carry on his father's warlike movements in Thrace and even outside the realms of Greece. He received suddenly the news that the Macedonian garrison in Thebes had been massacred, and he rapidly retraced his steps from the shores of the Danube, recaptured Thebes, slaughtered numbers of its defenders, and sold a far greater number into slavery. It is stated that Alexander indulged in the exultant declaration that Demosthenes had called him a child, but that under the walls of Athens he would prove himself, even to Demosthenes, to be a man.

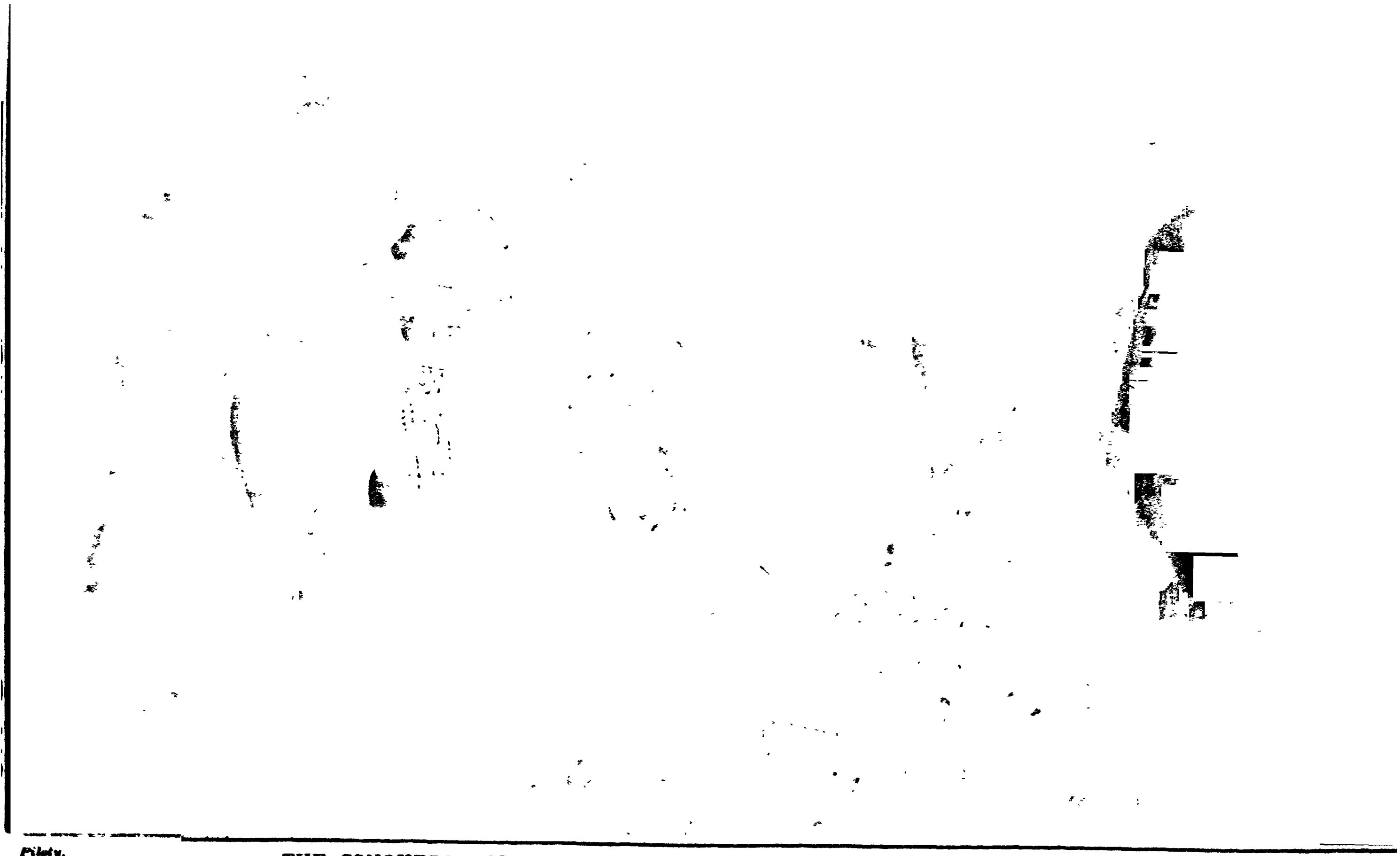
Many Conquests. The Greek states, now brought once again into submission, conferred upon Alexander the title, which his father had formerly held, of Commander-in-Chief for the conduct of the war with Persia. Alexander crossed the Hellespont with an army of 30,000 foot and 5,000 horse, and won a brilliant victory over the Persians near the River Granicus. The Persian army is stated to have numbered more than 100,000 men. The Persian ruler was Darius III., the descendant of the brilliant family, of whom Darius I. was the most famous. Darius III. began his reign in the year that saw Alexander the Great succeed to the throne. Alexander then continued his march along the coast in order to protect Greece from invasion by the foreign allies of Darius, and also to prevent Darius from receiving any assistance towards the repression of uprisings which might occur among his own subjects.

Darius, however, made more than one heroic attempt to check the movements of Alexander, but Alexander defeated him in another battle. Then the conqueror laid siege to the city of Tyre, which he captured after a protracted struggle. He made himself practically master of Egypt, and there founded the city of Alexandria, which he called after his own name. Some historians tell us that in order to conciliate the inhabitants he went so far as to make sacrifice to the accepted divinities of the region, not having any religious principles of his own strong enough to prevent him from performing this singular act of conciliation. He pursued his conquering way through Palestine and Assyria, traversed the Euphrates, where the Persians made no stand, and the Tigris, which they unsuccessfully attempted to defend; and on the famous battlefield of Arbela he won his third and decisive victory over Darius.

An Army of a Million. The army of Darius numbered nearly a million of men, while the Macedonian army had less than fifty thousand. Alexander became thus the possessor of a vast amount of gold and silver taken in the cities of Susa, Persepolis and Babylon, with large stores of jewels, the property of Darius, worth in all some thirty millions of our present money. The value of these spoils is estimated on the authority of Plutarch, one of the greatest of Greek historians, who began his life after the opening of our Christian era, and had thus ample time to collect and study his materials. There seems no reason to suppose the estimate extravagant, for Darius must unquestionably have had vast stores of wealth in that part of his dominions. Darius retreated to his eastern provinces, and Alexander, feeling certain of victory, made no effort to pursue him. The fate of Darius was soon decided. He was killed in his flight by one of his own satraps who had turned against him. Alexander came to Babylon, where he restored the temple which had been destroyed by Xerxes, and he occupied in succession all the other capitals of the late sovereign.

A Stern Conqueror. He was now sovereign of Persia, which he made merely a part of the Macedonian Empire, and he married Roxana, the daughter of a great Persian nobleman. Alexander did not show himself as merciful a conqueror during this part of his career as at its earlier stages. He exercised severe and even cruel reprisals upon some of those whom he believed to be conspiring against him. He was not yet satisfied with his conquests, and was filled with a strong desire to make India part of his Empire.

It happened that one of the sovereigns of a state in India was at that time engaged



Piloty.

THE CONQUEROR CONQUERED: THE DEATH OF ALEXANDER THE GREAT in a feud with another Indian monarch, who besought the aid of Alexander against his rival, and the Macedonian conqueror probably thought this a good opportunity for his Indian enterprise. Alexander won a complete victory over this Indian King, Porus; and to cross the Indus and thus come upon Porus, he caused a whole forest to be cut down in order that he might construct a fleet for the passing of the river. He dealt so generously with his captive, partly no doubt with the view of obtaining the genuine submission and alliance of Porus, that he allowed him to retain his states on condition that Porus should undertake the duty of keeping all that part of the country in obedience to Alexander's rule. The fleet Alexander had created had meanwhile coasted all along the shores, returning by the Persian Gulf, with the object of satisfying the trading world under Alexander's rule as to the facilities for opening up and carrying on an extensive commerce with India. Alexander, meanwhile, built ports, dockyards, and even cities in the territories he had subjugated, and when he returned to Babylon he led his army through deserts which had never before seen the march of a military force.

Statesman and Soldier. Alexander was a great statesman as well as a great soldier. He belonged to that supreme order of military conquerors who prove themselves to be the founders of imperial systems. He understood to the full that, no matter what military force he could obtain from Greece, it would not be within his power to maintain his rule over the Indian territories by any other means than that of liberal and equal laws. Throughout his rule he showed respect for the national customs of the peoples he had conquered, allowed them to maintain their own religious worship, even on certain occasions offering formal homage to their gods. He promoted as far as possible the marrying of Macedonians with Asiatic women, and he did his best to promote a continuous commerce between Greece and the East.

Alexander was still a young man, only thirty-two years of age, and might well have seemed to be still approaching to yet greater conquests. His purpose evidently was to bring Greece into close commercial, political, and military alliance with Persia and the other Asiatic states which he had conquered, and thus to create one vast Macedonian Empire, spreading over much of the West and of the East.

The Death of Alexander the Great. While at Babylon he was suddenly stricken by a disease which came upon him after a luxurious banquet. His illness was probably malarial fever. But Alexander took little account of it, continuing to indulge in heavy drinking; and on the eleventh day of his illness it became evident to those around him that the great career was coming to a close. The portents of the tragedy soon spread; the soldiers crowded into the Royal palace, and many of them were allowed to pass in file beside the bed of their Commander. Alexander was then unable to speak, and could only wave his hand in friendly acknowledgment of their presence. He had before this become certain that his end was near, and had given his ring as a memorial to Perdiccas, one of his lieutenants and friends. When some of those near him asked him to whom he desired to leave his crown, he murmured that he desired to leave it to the most worthy, and that his only fear was lest bloodshed should follow his funeral rites. Then came the end.

A Great Policy. Alexander's reign of conquest had lasted little more than twelve years. He was one of the greatest conquerors the world has known. We can clearly discern, from what is told us by the historians who came nearest to his time, that he had far higher and more statesmanlike projects than those of mere conquest and subjugation by military and despotic power. His policy was to treat the conquered countries with such equity and generosity as might make them his willing and loyal subjects; to endow them with systems of government under which they should be more free and prosperous than they had ever been before; to give them political and social equality, and to make it a personal and patriotic interest with them to become free citizens of his Empire. He had many faults, some of them great faults. He had a vehement and sometimes ungovernable temper, and although in his better moods he was conscious of this defect and strove to control it, there were times when it passed beyond his control and drove him to deeds unworthy of such a man.

Murder of Clitus. One of these deeds was the slaying with his own hand of his friend Clitus, who had saved his life at the Granicus. Alexander and Clitus and their brother officers were banqueting together, and many of the officers paid compliments to Alexander in language which seemed to the plain and sincere nature of Clitus to be that of the most fulsome flattery, such as Alexander ought not to hear without reproof. Clitus expressed his opinions strongly, and when Alexander, roused to anger, rebuked his friend for such interference, Clitus reminded him that the sovereign owed his life to the hand of his friend, and further told him that if he would not endure a just remonstrance he ought to associate only with slaves. Thereupon Alexander, who had probably been drinking very heavily, sprang up and stabbed Clitus with a javelin. The wound proved mortal, and it was said that Alexander never, during the remainder of his life, ceased to repent the crime, committed in the fury of the moment, which had cost him the life of his best and most devoted friend. Many other evil deeds, the result of sudden ungovernable passion, are recorded against Alexander, and although he was usually magnanimous as a conqueror, yet he is accused of having been sometimes guilty of actual cruelties towards those whom he had subjugated

Alexander's was undoubtedly one of those uncertain natures which do not improve by continuous prosperity. Disappointment and what seemed to be the frustration of his plans he always bore manfully, and studied how to put things right and carry his enterprise to success in spite of overwhelming obstacles. But when victory had been accomplished Alexander was only too ready to indulge in the exultation of the hour, and allow his worst impulses to exert their full influence over him. We meet often in everyday life with men who can devote themselves to some great task in art or literature, or in commercial enterprise, with persevering spirit and unshadowed front until that work be fully accomplished; and will then give themselves up to an interval of sensuous enjoyment, and allow the worst impulses of their nature to have unchecked expression, as if such a time were a well-earned holiday after the strain of their toil.

A Complex Nature. Alexander appears to have been such a man. There were in his nature two different men—one whom nothing could turn from his enterprise until it had been accomplished, and one the voluptuary who was then allowed to assert his own prerogatives for the time. But it must remain to his eternal honour that wherever he went as a conqueror he endeavoured to spread the language, the literature, the art, and the civilisation of Greece. Even his occasional toleration and patronage of idolatrous practices and of polygamous habits, which gave occasion to much condemnation by historians, may be set down to his strong desire to gain the confidence of each newly conquered people, to induce them to regard him as sympathetic and friendly, and thus win them to become his peaceful and loyal subjects.

The body of Alexander was buried in a golden coffin at Alexandria. The extent of his conquests, if studied on a map, must seem wonderful when we remember the undeveloped condition of travel in those far-off days, and the almost superhuman difficulties which a conqueror must have had to encounter in transporting his armies through vast regions of unexplored forest and swamp, and in using his rudely made timber fleets for the conveyance of large numbers of men across the seas. The weapons of a civilised army in Alexander's time had but little superiority over the weapons of the uncivilised tribes who strove to oppose his progress, and in the genius of the conqueror himself must have been found the sole key to success. The events that followed the death of Alexander bear the strongest evidence of the right he had to that title which has been universally given to him—Alexander the Great.

An Illustrious Era. The era to which belong the reigns of Philip and Alexander is one of the most illustrious in the history of the ancient world. It was not only—it was not even mainly—an era of conquests; it was an era of letters, of art, of oratory and philosophy. Soon after the death of Alexander the genius of conquest began to pass away from Greece. Alexander's death led to a quarrel as to the succession. His wife Roxana gave birth to a son three months after Alexander's death, and this son, in the ordinary course of things, would have succeeded to the throne, but Alexander had also a half-brother named Aridæus, who claimed the succession. The mother of Alexander was still living and took an active part in the dispute. There was, in fact, a family controversy over the succession, and in the end it was agreed upon, as the only possible compromise, that Alexander's son and Alexander's half-brother should both be proclaimed sovereigns. This division of a nominal authority between an infant and an incapable youth only led to incessant family disputes, which soon broadened into public divisions and international disorders. The Macedonian Empire broke asunder, state after state striving to restore its long-lost national independence. For many years this struggle went on, and Macedonia had to resist invasion from all sides. Meanwhile a new power was arising in Europe which was to make itself felt all over the world—the power of Rome. Macedonia became in the course of time a province of Rome, and the Macedonian Empire was heard of no more.

The Teacher of the World. This is a suitable time at which to make a retrospective survey of the great works which were accomplished in art and literature, in philosophy and in statesmanship, during the days of that Macedonian Empire. The name of Socrates may well hold the foremost place among those who thus made Greece the teacher of the world. Socrates was the son of a sculptor, and was brought up in Athens, where he received the education usually given to young Athenians, but learned in addition, what was not then common, a considerable knowledge of geometry and astronomy, in which he took a deep interest. He served as a soldier in three campaigns, and displayed much courage, energy, and patient endurance; and it is said that he amazed his more experienced war comrades by his absolute indifference to the bitter cold of a winter campaign as well as to its danger.

A Bold Philosopher. He followed his father's occupation as a sculptor, and is credited with having accomplished a marble group which was exhibited in the Acropolis. After a while he abandoned all occupation but that of a teacher of philosophy, and this he taught not in schools, as other philosophers of his time had done, but in the public Forum, in streets and market places, in his own home, and in the homes of his friends. He preached a more enlightened form of religion than that authoritatively accepted in his day; he condemned intolerance of other men's faiths, and he inculcated doctrines of righteousness and purity, and the need of a constant pursuit of knowledge. Socrates would really appear to have believed himself inspired by some higher power as an expounder of philosophy, morality, and religion, and he spoke out his sentiments with a boldness which soon made him dreaded and detested by the rulers of the state. Finally, he was made the victim of a legal impeachment on the ground that he was guilty of blaspheming the recognised divinities of Greece, of endeavouring to introduce to the people new and false gods, and of striving to corrupt the morals of the Athenian youths. He delivered a speech in his own defence, and the courage and eloquence with which he defended his cause probably aroused the pitiless hostility of the tribunal before which he had to plead. Although the vote of condemnation against him was only carried by a small majority, the court condemned him to die by drinking a cup of hemlock. When the appointed time came he quietly drank the hemlock, and died with all the composure of a philosopher and a martyr. He thus passed out of life in his seventieth year nearly 400 years before the Christian era.

Another Great Philosopher. Plato was one of the greatest among the Greek philosophers. There is some doubt about the place of his birth. The general belief is that he was born in Athens, but it is also contended that his birthplace was in the neighbouring island, Ægina. The dispute is not of much importance, for Plato must in either case be regarded as an Athenian. He was born of aristocratic family, and appears in his youth to have begun by writing poems; but he soon applied himself to the study of philosophy, and when he was nearly twenty years old he became the friend and companion of Socrates. That friendship lasted for some eight years, and the companionship was then brought to an end by the death of Socrates. After the death of Socrates, Plato left Athens and visited Sicily, parts of Italy, and even Egypt, striving wherever he went to add to his store of knowledge. Knowledge was indeed the one object of his ambition. He showed no inclination for practical politics, he loved learning not merely for its own sake, but because he believed that through learning alone could man know how to live a truly noble and virtuous life.

The Teachings of Plato. Plato began his career as a teacher. He taught in the Academy, a public exercise-ground planted with noble trees, and from his teachings there his school of philosophy became known as the Academic. Plato also explained and expatiated on his philosophic doctrines in his own gardens, where he could always gather round him a large number of disciples and friends. Plato's teaching was to a great extent a continued exposition of the doctrines taught by Socrates, but he made a more systematic effort to associate them at once with the practical life of man and with man's higher life in the future. Plato contends that man's highest ideal is the recognition of "the good." His interpretation of "the good" corresponds with that given by Christianity. He would not admit that pleasure is man's good, but on the other hand he would not adopt the principles of the Cynic philosophers, that all pleasure is in itself an evil—a doctrine which has to a great extent been accepted by the teachers of many sects from that time to the present. He held that pleasure was good or evil according to its nature, and to those elements in the mental and moral constitution of human beings which it could help to improve or to spoil. Plato lived to a good old age. He died in his eighty-first year, and was seen by his friends for the last time at a wedding feast. He died as he had lived through the greater part of his life—in peace and in an atmosphere of happiness and hope.

Aristotle. Aristotle was the greatest pupil of Plato and one of the greatest philosophers of all time. He was born at Stagira, a Greek colony. In his eighteenth year he settled in Athens, and soon after became a pupil of Plato He founded a school of rhetoric in Athens. The teaching of rhetoric included a certain amount of instruction in law and in politics. When Plato died Aristotle left Athens and stayed for some years in Asia Minor with an old pupil who had now become a man of power. He was afterwards invited to Macedon by Philip that he might educate Philip's son, Alexander, and he continued to be the instructor of Alexander for three or four years. When Alexander started on his expedition into Asia, Aristotle returned to Athens, and there founded a school called the Lyceum, because it was near to the temple of Apollo Lycieus. After the death of Alexander, his friend and protector, his teachings were regarded with disfavour by a powerful party in the Athenian state who were uncompromising opponents of the Macedonian policy and prejudiced against Aristotle, whom they regarded as one of those who favoured it He was accused of impiety—of endeavouring to set his pupils against the ancestral divinities and ancestral faith. Aristotle knew from what had befallen Socrates how easy it was to convict of impiety anyone who endeavoured to inculcate a new religious doctrine. He escaped from Athens and took up his residence at Calchis, in Eubœa, a large island in the Ægean Sea, which had become subject to Athens and is now part of the kingdom of Greece. Aristotle was not given long to enjoy the quiet of his retirement, for not many months after he died at the age of sixty-two.

Other Greek Schools of Philosophy. There were many other philosophers and schools of philosophy in the great days of Greece. There was Zeno, the originator of the Stoic philosophy; there was Diogenes, the Cynic philosopher, who in his maturer days turned so completely against the extravagant living of his youth as to make it his theory that man ought to subdue by hardship and physical pain all his sensuous cravings, and finally, according to the common report, made his habitual home in a tub.

We have already said something about the poetry and the art of Greece, about her orators and historians, and have only to add that the closing days of the independence and power of the Greek states were the greatest days of Grecian genius since the earlier time when the poems of Homer were given to the world, and that Greece, when she passed for ages out of history, passed away at least in a blaze of light.

Continued

THE BOOKS OF THE FIRM

Entries of Petty Cash and Stamps. Examining Invoices. Day, Invoice, and Cash Books. Treatment of Sale and Discount Transactions

Continued from page [illegible]

By A. J WINDUS

THE reason why Bevan & Kirk call their principal register of receipts and payments *Bank Cash Book* is to emphasise the fact that all transactions recorded therein pass through the firm's banking account. An inspection of the entries on folio 45 will reveal this more clearly. On September 21st, 1905, two amounts were received of £1 5s. 9d. and £5 4s. 8d., respectively, and these were paid into the bank as one total of £6 10s. 5d. So it is with all the receipts; they are banked on the same day they arrive without any deduction.

Petty Cash. If money is wanted to pay petty expenses, a cheque is drawn and cashed (as on September 20th), and the junior clerk enters in his petty cash book particulars of the cash received and of the manner in which he gradually disposes of it. Trade creditors, except for small sums, are paid by cheque, the creditor's own signature on the back of the cheque (styled an endorsement) being an excellent form of receipt. Could anything be more charmingly simple than this system of dealing with the cash? All the money which comes in is debited to the bank, because the bank *receives* it—every penny of it—and all the cheques drawn, whether for petty cash, trade creditors, or any other purpose, are credited to the bank because the bank *pays* them. [See Bookkeeping Rules *a* and *d*.]

We now understand what effect was produced upon Bevan & Kirk's banking account by the withdrawal of £90 in September last for petty cash. The bank paid the various demands made upon it, and was therefore credited, petty cash being debited with the corresponding amounts. £60 of the total is involved in the amount of £355 14s. 7d. brought forward in the bank cash book. Our copy of this book does not go back far enough to enable us to tell how the £60 was made up, but we do know that, since September 19th, an additional £30 has been drawn for petty cash—namely, £5 on September 20th, £15 on September 23rd, and £10 on September 30th; that is to say, £90 in all. We might now, of course, post the bank account to its niche in the general ledger, but the time for that is not yet.

Stamps. Although we are naturally anxious to perceive the true bearing of a series of transactions (such as we have in the banking account of Bevan & Kirk), and to give it due expression in terms of debit and credit, and finally to distribute the debits and credits among the ledger accounts concerned, we must not overlook a certain set of transactions which still claims our attention. Nor must we forget that we are dealing at the moment with books of original entry. It will be time enough to look into the ledgers when we have prepared the entries in the former for posting to the latter.

Transaction (*b*) in our list is a humble one. To discuss postage stamps after reviewing a flourishing bank account is like descending to the valley after climbing the mountain peak. Nevertheless, it is perfectly certain that office-boys and junior clerks who put careless and slovenly work into the postage book are throwing away chances of self-discipline and future advancement. This book is as much a book of account as the petty cash book, while, as may be seen from the specimen given on page 194, it contains other information useful for reference.

With regard to the item of 5s. for stamps purchased on September 20th, the usual practice is for the junior clerk to hand the money to the post-boy to be laid out in stamps and duly accounted for. The junior clerk then enters the amount in the payment or credit column of the petty cash book—*q.v.*, because cash goes out; and, at the same time, the post-boy enters 5s. under date of September 20th in the left-hand or "Received" column of his postage book, because, from his point of view, cash comes in. Then, in the payment column, he enters, day by day, postages on letters, etc., until he is in danger of exhausting his stock of stamps, when he goes to the junior clerk for more money. In this case the junior clerk unites both offices in his own person, but that makes no difference to the procedure.

The Invoice. Transaction (*c*), Sept. 21. Invoice received from Ord & Mackay for £57 10s.

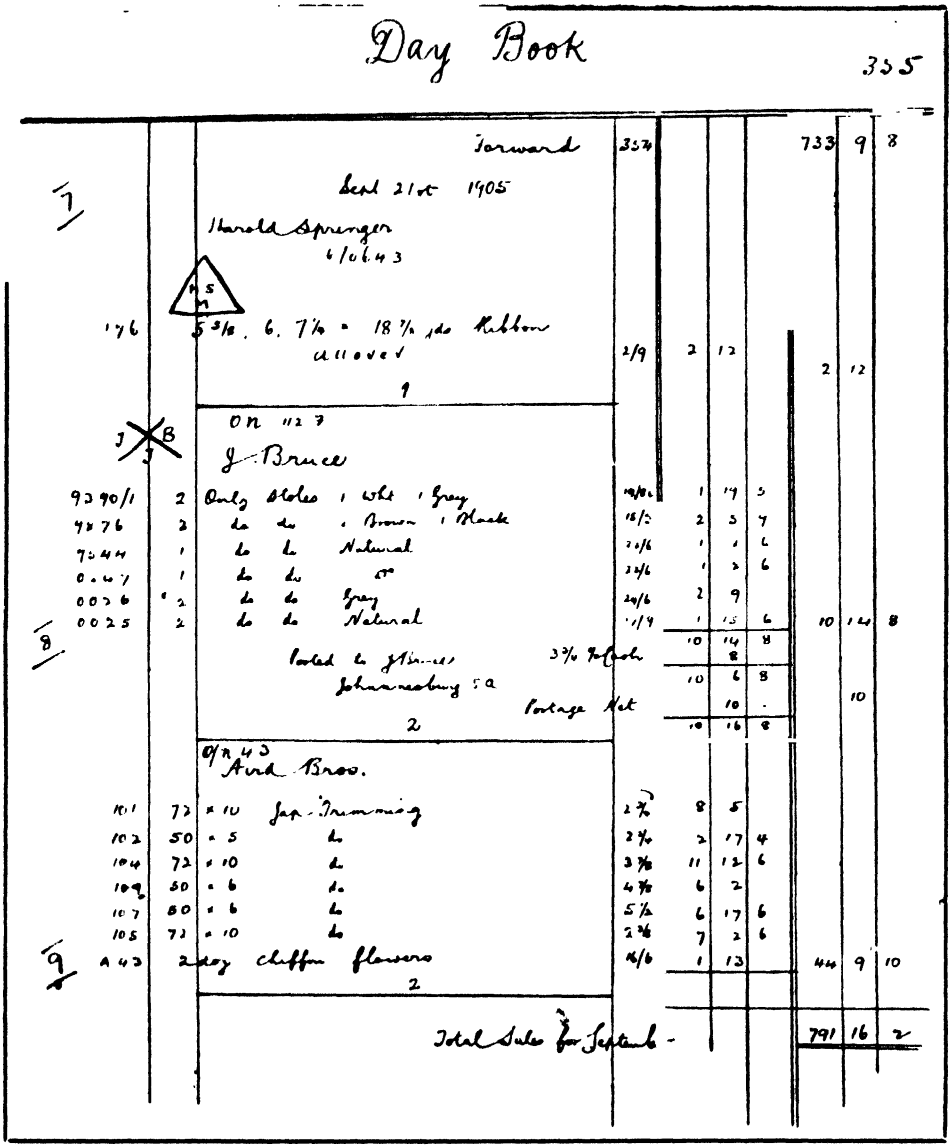
An invoice cannot be dealt with until the goods to which it relates have arrived.

Before our invoice can be entered it has to submit to a species of cross-examination. It has already undergone a direct examination by the senders, Messrs. Ord & Mackay, to ensure, as far as possible, that everything was in order at the time of its despatch. The questions put to the invoice are these:

1. Is order number given?
2. Are the goods properly described?
3. Are the quantities and measurements correct?
4. Are the prices right?
5. Are the extensions and casting correct?
6. Has the agreed trade discount been deducted?
7. Are the terms and dating correct?

These questions are not all asked by the same person, but whenever a satisfactory answer is obtained it is acknowledged by the *examiner's* initials.

The court of appeal for both parties is the



Day Book

355

			Forward	354				733	9	8
			Sept 21st 1905							
7			Harold Sprenger 6/06.43							
	176		5 3/8, 6, 7⅛ = 18⅞ yds Ribbon allover	2/9	2	12		2	12	
			1							
			On 1127 J. Bruce							
	9390/1	2	Only Stoles 1 Wht 1 Grey	19/10	1	19	5			
	4876	2	do do 1 Brown 1 Black	15/2	2	5	7			
	7544	1	do do Natural	21/6	1	1	6			
	0.47	1	do do do	22/6	1	2	6			
	0026	2	do do Grey	24/6	2	9				
8	0025	2	do do Natural	11/9	1	15	6	10	14	8
					10	14	8			
			Posted to J. Bruce Johannesburg S.A. 3% for Cash			8				
					10	6	8			
			Postage Net			10	.		10	
					10	16	8			
			2							
			O/n 43 Aird Bros.							
	101	72	× 10 Jap Trimming	2¾	8	5				
	102	50	× 5 do	2¾	2	17	4			
	104	72	× 10 do	3⅛	11	12	6			
	109	50	× 6 do	4⅞	6	2				
	107	50	× 6 do	5½	6	17	6			
	105	72	× 10 do	2⅛	7	2	6			
9	A43	2	doz Chiffon flowers	16/6	1	13		44	9	10
			2							
			Total Sales for Septemb-					791	16	2

original order sent by Bevan & Kirk and accepted by Ord & Mackay. To its provisions both the invoice and the goods themselves must conform. If there is any shortage, damage or error in the goods, Bevan & Kirk may send a *debit note* to Ord & Mackay charging them with the amount of the loss. On the other hand, Bevan & Kirk may ask Ord & Mackay to send them a *credit note*, crediting them with the amount of the loss. The result is the same either way. Bevan & Kirk obtain an abatement from the total of Ord & Mackay's invoice proportional to the damage they have sustained. Assuming, however, that everything is in order, the invoice passes into the keeping of the accountant, who gives it a serial number (808) marked boldly in blue pencil on the face of the invoice. He tests the arithmetical accuracy of the invoice, or the junior clerk may do it for him, and then the next thing is to enter it in the Invoice Book in readiness for posting to the account of Ord & Mackay in the Bought ledger.

INVOICE BOOK

	1905	September, 1905.				
808	Sept. 21	Ord & Mackay		57	10	0
850	30	Do.		46	15	3

The entry made, the invoice is placed with the other September invoices until the monthly statements of account come in; then, if any discrepancies arise between the statements and the ledger accounts, the invoices are referred to and matters put right. After this the invoices are filed away in a bundle or box by themselves. By some accountants they are kept loose until the statements, having been paid, come back receipted. The invoices belonging to the several statements are then attached thereto, and the papers are put in among the vouchers, which seems a good way of dealing with them.

Cash Sale. Transaction (*d*), September 21st. Mr. Allday purchased for cash goods value £1 5s. 9d. This is a class of transaction met with in every business. The simplest way of looking at it is to treat it as a cash sale (C. S.). It is a mere accident that we know the name of the purchaser. We should, of course, want the information if we had sold the goods on credit, but not now. All we need think of is that cash came in (debit Cash), and goods went out (credit Sales). Accordingly we shall find the entry in our cash book so arranged.

Transactions (*e*), (*f*), (*g*). Goods were sold on credit as follows:

			£	s.	d.
(*e*)	Sept. 21.	Harold Springer	2	12	0
(*f*)		J. Bruce	11	4	8
(*g*)		Aird Bros.	44	9	10

These three transactions belong to one class—that of sales. Therein they differ totally from (*c*), which was a purchase. We have already explained that the system adopted by Bevan & Kirk in connection with their credit sales is to enter them at convenience throughout the day in the sales day book, the several invoices being copied therefrom.

The entries will appear in the day book as in the Table given herewith.

Our study of selected transactions will be resumed in due course, and thereby an excellent opportunity will be created for earnest students to grapple with the transactions lettered (*h*) to (*u*). It should be pointed out that for the sake of simplicity a record of transaction (*t*) has been inserted in the invoice book in anticipation.

Relation of the Journals. Those of us who are readers of thrilling romances like "Ivanhoe" or "The Wandering Jew" know well enough that story-tellers often leave the hero or chief character in desperate plight while they invite us to follow for a season the adventures of the minor characters. This practice is styled "gathering up the threads." We have sometimes rebelled at such treatment as being a mere stage device, knowing in our hearts, however, that it was essential to the unity and equipoise of the story as a whole. Something of this sort happens in the study of bookkeeping, which, though not a romance, may lay claim to its heroes—which are the ledgers; its principal characters—which are the books of original entry; its minor characters, the supplementary records. To change the metaphor, all parts of our subject must advance by regular steps. We cannot storm the citadel until we have captured the outworks. Hence, we have proceeded on the assumption that when all the journals are understood, it will be easy to learn how to keep the ledgers.

The Cash Book. By journals we mean the books comprised in the list of "books of original entry" [see page 778]. One of the most important of such journals is the cash book. Many authorities deny that the cash book is a journal, and as soon as we are well grounded in the principles of double-entry we must examine their contention, with a view to deciding which is the more scientific theory.

Discount Transactions. Whether we speak of the cash book as a journal or as a part of the ledger bound up separately is immaterial, so long as its form and functions remain the same.

We are already familiar with the form and ruling of a cash book, a specimen folio having been given in the last chapter, when we were dealing with some typical transactions of the firm of Bevan & Kirk. Continuing our study of these we come to:

> Transaction (*h*), September 22nd. Received from Messrs. Brown & Co., Ltd., cheque, value £10 1s. 9d., in settlement of account £10 6s. 11d., less 2½ per cent.

So many of Bevan & Kirk's customers avail themselves of discount terms that a discount column has been ruled on the left-hand side of the cash book on purpose to accommodate items of discount allowed. Each item is entered in a line with the cash item to which it relates; thus, Messrs. Brown remitted £10 1s. 9d., in payment of an account of £10 6s. 11d.—that is, they deducted 5s. 2d. discount, being 2½ per cent. on the latter amount. Since, to Bevan & Kirk, the cheque is a *receipt*, the value of it is entered on the receipt or debit or left-hand side of the cash book, and in a line therewith on the same side, discount 5s. 2d. is entered in the discount column. All this, of course, is a mere preparation for posting in the ledger itself.

Group 13

GEOGRAPHY

7

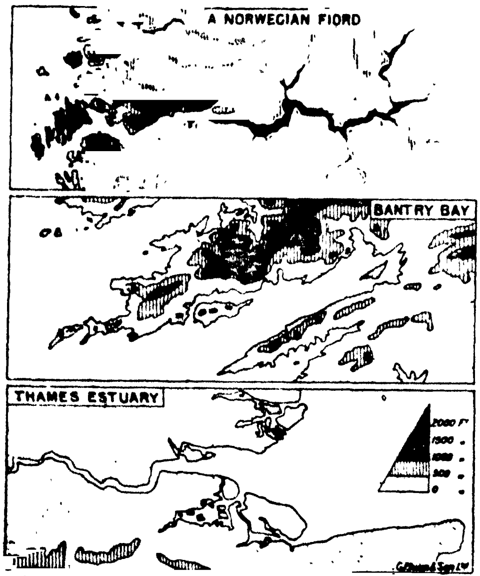
Continued from page 894

OUR OWN COUNTRY

Position, Form, Structure, and Climatic Conditions of our Islands. Vegetable, Animal, and Mineral Productions, with their Distribution

By Dr. A. J. HERBERTSON and F. D. HERBERTSON, B.A.

The British Archipelago. Britain, or the British Isles, consists of the large island of Great Britain—divided into Scotland in the north, England and Wales in the south—and the smaller island of Ireland lying to the west. The least distance between the Scottish and Irish coasts is only about 14 miles, the shortest regular service is 35 miles, and the mail route to Kingstown, near Dublin, rather over 60 miles. Lying off these two main islands are many smaller ones, of which notice the Orkneys and Shetlands, lying north of the extreme north-east of Scotland, the Hebrides and other islands fringing its west coast, the Isle of Man in the middle of the Irish Sea, Anglesey, separated from Wales by the narrow Menai Strait, the Scilly Isles off the extreme south-west of England, and the Isle of Wight off the South Coast, near the middle, separated from the mainland by the narrow straits of the Solent and Spithead. The Channel Islands, near French waters, are politically, though not geographically, part of Britain. Altogether there are over 5,000 islands in the British Archipelago, many of which are mere uninhabited rocks.



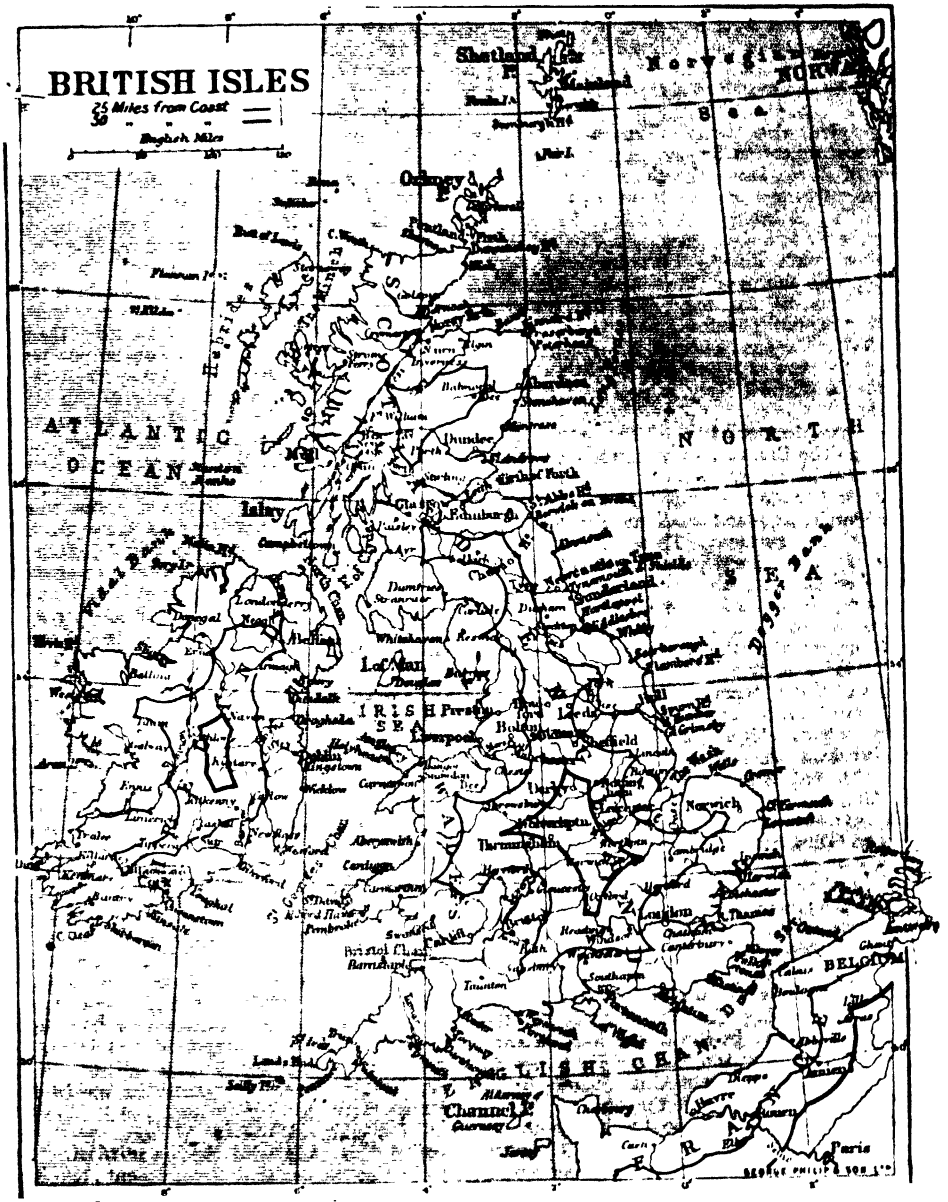
65. BRITISH COASTS AND A NORWEGIAN FIORD: A COMPARISON

The British Seas. West of the British Isles is the Atlantic Ocean, separating them from the New World by nearly 2,000 miles of ocean. Ireland, separated from Great Britain by the shallow Irish Sea, which is entered from the Atlantic by the North Channel in the north and by St. George's Channel in the south, lies like a breakwater off the central portion of the larger island, shielding half of its western coast from the full force of the Atlantic storms. The eastern shores of Great Britain are washed by the shallow North Sea, which opens by the narrow strait of Dover into the English Channel. These shallow seas are unfortunately dangerous to navigation owing to the numerous sunken rocks and sandbanks, of which the Goodwin Sands have perhaps the most infamous reputation. The Dogger Bank, covered by shallow seas, about 80 miles off the Yorkshire coast, is a rich fishing ground, visited by fishing fleets from the surrounding lands.

The British Coasts. The Atlantic coasts differ considerably in character from those of the more confined seas. The former are, as a rule, rugged, mountainous, and deeply cut into fiords and islands. Here the sea has drowned the lower ends of the valleys, partly probably through the gradual sinking of the highland areas. These deep inlets are called loughs in Ireland, and firths or lochs in Scotland. A glance at the map shows how characteristic they are of the Atlantic coasts, not merely of Britain, but also of Norway. The coasts surrounding the confined seas, on the other hand, are, as we should expect, generally low, and often sandy, with high cliffs only where the highlands come down to the sea. The famous white cliffs of the South Coast, dear to the wanderer homeward bound, are the edge of the low chalk heights of southern England. The rivers flowing to the shallow seas from long estuaries are quite different in scenery and mode of formation from the fiords of the Atlantic coast [65], though on a map they look very similar.

The coasts, therefore, both of the Atlantic and of the shallow seas, are deeply penetrated by water, so much so that no place in the British Isles is 100 miles from the nearest sea [66]. The deep estuaries wind far into the land, permitting ocean-going ships to discharge their goods almost in the heart of the country.

There is a remarkable though accidental symmetry in the situation of some of the more important of these openings, which are arranged, as it were, in pairs. In the South of Scotland the head of the Firth of Clyde on the west is only about 25 miles distant from the head of the Firth of Forth on the east. Similar pairs are the Mersey and Humber, about 80 miles apart, and the Severn and Thames, 160 miles apart. Communication between the eastern and western seas by ship canal would consequently not be a very difficult matter.



66. THE BRITISH ISLES AND THE SEA

Showing the accessibility of the interior portions to the sea

Position of Britain in Relation to the Continent. Britain is a fragment of the mainland of Europe, cut off from France, her nearest Continental neighbour, by the submergence of the Calais-Dover isthmus. The shores of France are clearly seen from Dover, which is only 22 miles from Calais. Note also (1) that the estuary of the Itchin, or Southampton Water, is opposite the estuary of the Seine in northern France, from which it is just over 100 miles distant; (2) that the estuaries of the Thames and Stour on the east coast of England are exactly opposite the mouths of the Rhine on the opposite coast of the North Sea, at approximately the same distance; and (3) that the estuary of the Humber further north on the east coast of Britain is opposite the estuary of the Elbe in Germany, though in this case the distance is not far under 400 miles. Britain, therefore, is insulated, but not isolated, as has been wittily said. Her island position protects her against invasion by land, and saves her many costly military burdens. On the other hand, the warder seas are not too broad for her to keep in touch with the march of civilisation and ideas in Europe.

Bridging the Seas. The estuaries which help communication by sea impede it by land. Some of these have therefore been bridged, and others tunnelled. In Scotland the estuary of the Tay is bridged at Dundee by the Tay Bridge, over two miles long. Further south the towering Forth Bridge, 1½ miles long, unites the opposite shores of the Forth. The Menai Bridge connects Anglesey with the mainland. The Severn and Thames are both bridged and tunnelled. Various schemes are suggested for uniting the two sides of the English Channel. Of these a channel ferry is probably the most feasible.

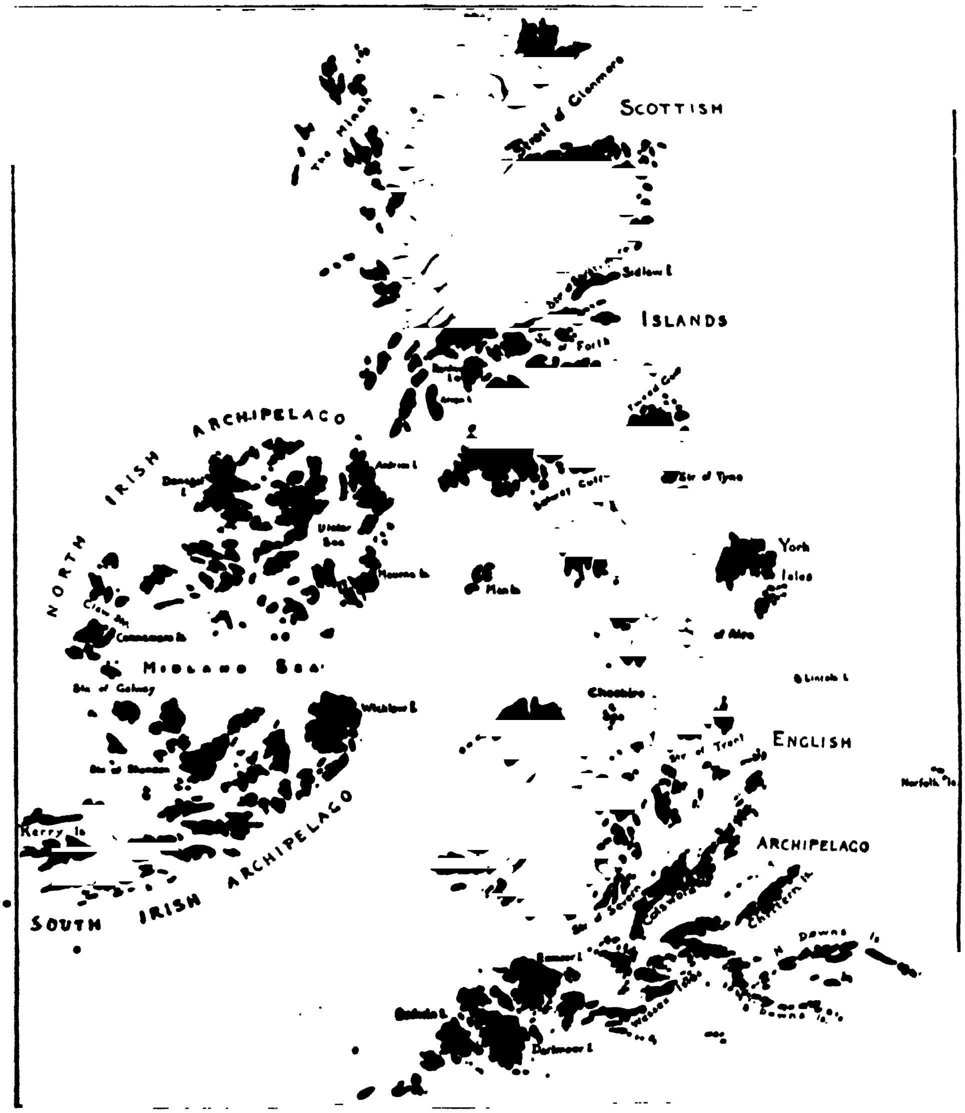
An Imaginary Map of Britain. If the sea round the British Isles were to rise 600 feet, the present islands of Great Britain and Ireland would be transformed into an archipelago of many islands, large and small, most of them very irregular in surface. These islands would represent those parts of Britain at present more than 600 feet above sea-level. The seas separating them would represent the parts at present less than 600 feet below sea-level. Fig. 67 shows what the new map of the British Isles would look like. Beginning in the north we should have, where Scotland used to be, two large islands separated by a long, very narrow strait. These would represent the North-western and Grampian Highlands respectively, and might be called North Island and Grampian Island. The long, narrow strait between—a mere silver streak—would represent Glenmore—the Great Glen—the long, narrow valley at present filled by a chain of lakes connected by the Caledonian Canal [67]. South of Grampian Island a stretch of broader sea, in places nearly 50 miles wide, covering the broad valley which has been riven by movements of the earth's crust between the mountains on either side, would be studded by islands representing the Campsie Fells, the Ochils, and others. In the east a long, narrow island, representing the Sidlaw Hills, would be separated from Grampian Island by a broadish strait representing the present vale of Strathmore. Still further south the mountains of southern Scotland, the Southern Uplands, would form a large, irregular island, separated from islands representing the northern uplands of England, by a narrow strait similar to that of Glenmore, and representing the present Eden and Tyne valleys.

Imaginary Islands. The northernmost of these English islands, North Pennine Island, representing the mountains of Cumberland and Westmorland, and the Northern Pennines, would be cut by deep arms of the sea, representing the Eden and Lune valleys. An extremely narrow strait, corresponding to the valley of the Aire, would separate North from South Pennine Island. Off these, to the east, separated by a broad strait covering the present vale of York, would lie a group of islands representing the Yorkshire Moors and Wolds, while off the south-west would be a large compact island, representing the Cambrian Highlands of Wales, separated from the South Pennine Island by a broad strait covering the present counties of Lancashire and Cheshire. South of the Island of Cambria, and separated from it by seas somewhat broader than the present Bristol Channel, would rise islands representing Exmoor, Dartmoor, Bodmin Moor, and other heights of Devon and Cornwall.

Eastern Heights. The islands in the seas to the east of these islands—east of a line drawn on our present maps from the mouth of the Exe in Devon to the mouth of the Tees in Northumberland—would be small and far apart; while east of a line drawn from the head of the Humber estuary to the head of the Thames estuary solitary islets would represent the hills of Norfolk. Most of the islands of what we may call the English Archipelago would lie in roughly parallel lines, running from south-west to north-east. The most northerly of these chains of islands would represent the heights, often rising steeply from the plain, which separate the basin of the Severn to the west from that of the Thames to the east, the highest being the Mendip Hills of Somerset, and the Cotswolds of Gloucestershire. The next chain, with their chalk cliffs, would represent the chalk heights of Dorset and Wilts, the Chiltern Hills, and the heights of Bedfordshire and Cambridgeshire, while many of the straits between them would correspond with the valleys of the Thames and its tributaries. A crescent-shaped group of small islands still further south, also with chalk cliffs, would represent the present North and South Downs.

In Ireland we should have two archipelagoes of islands of no great size, separated from each other by a Midland Sea at least 60 miles wide, unbroken by islands except in the west. The Northern Archipelago would include the mountains of Ulster and Northern Connaught, the Midland Sea would represent the midland plain, of which a line drawn from Dublin Bay to Galway Bay is approximately the southern boundary, while the islands of the Southern Archipelago would represent the mountains of Munster and South Leinster.

The Actual Map of Britain. Comparing this map with the present relief map of Britain we see that Great Britain, the larger island, consists of two very different portions divided from each other by a diagonal line running from south-west to north-east. North and west of this Exe–Tees line lies a highland region, with few lowlands. South and east of the Exe–Tees line is a lowland region, with few highlands. The highland region consists of older, harder rocks, and is related in structure to the mountains of Scandinavia. The lowland region is formed of younger, softer rocks, which have been worn away over a large part of its area, leaving the three lines of heights already mentioned. This part of Great Britain is akin



67. THE BRITISH ISLES SUBMERGED TO THE HEIGHT OF 600 FEET
The actual coastline forms the 100-fathom depth-line, or edge of the Continental shelf

to the neighbouring mainland, and forms part of the European lowland. Ireland is a plain diversified by heights, and not a highland region divisified by lowlands.

The Lowlands of Scotland. We must now notice more in detail the position of the lowlands, for in these the population of the country is concentrated. Observe how the north-west of Scotland and the adjacent islands are almost entirely highland. There are lowlands in Lewis, the largest island of the Hebrides, in Islay, Arran, and others; but on the west coast of the mainland, as far south as the Firth of Clyde, the mountains come right down to the sea. In the east are the small lowland of Caithness in the far north and a narrow coastal lowland which runs almost unbroken south round the Moray Firth, and widens in Elgin and Banff to the lowland of North Aberdeenshire, with its group of busy towns. The area of these small lowlands is inconsiderable compared with the great compact mass of the highlands. In such a country, therefore, consider the value of the natural rift of Glenmore, which affords a unique means of communication between east and west. Equally clear is the importance of the Tay valley, which connects the Highlands with the

Midland Plain of Scotland, where the population of the country is concentrated. In this plain, which extends, broken by numerous heights, from the estuary of the Clyde to the estuary of the Forth, lie, as we should expect, almost all the important towns of the country.

To the south of it the Southern Uplands widen out again, with coastal lowlands in the east and west. The eastern lowland narrows abruptly where first the Pentlands and then the Lammermuirs approach the sea, making Edinburgh, at the base of the Pentlands, the key of Scotland, and Dunbar, at the base of the Lammermuirs, the key of Edinburgh. The Cheviot Hills connect the Southern Uplands with the Northern Uplands of England. Throughout this region the lowlands are chiefly associated with the river valleys. Notice the importance of these means of communication. The valleys of Annan and Clyde provide a direct route to the north; the Tweed valley—the only populous part of the southern uplands—opens up the country from east to west; and a route to the south is afforded by the valleys of the Teviot, a tributary of the Tweed, and of the Liddel, flowing to Solway Firth.

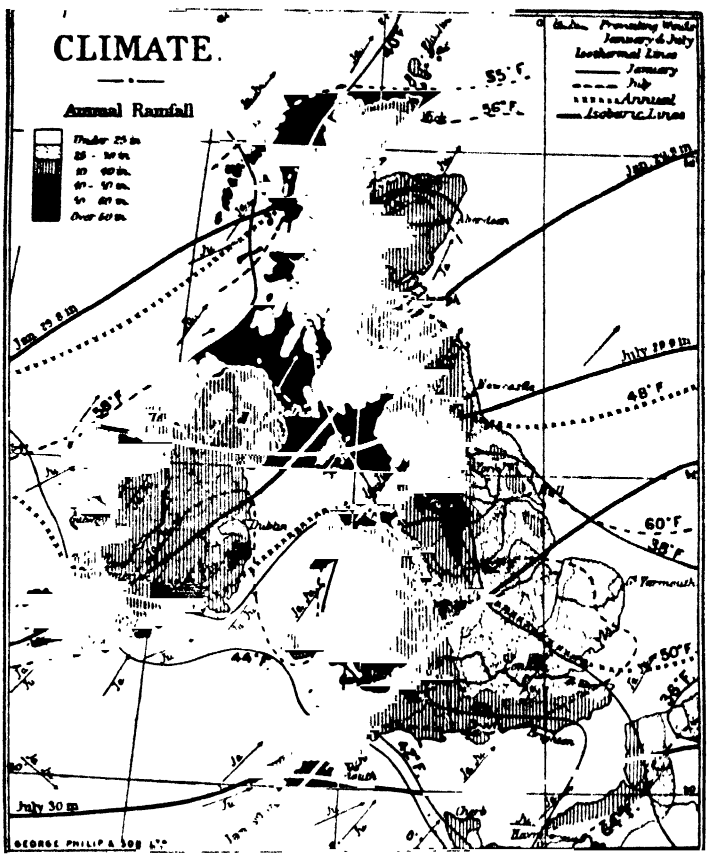
The Lowlands of England and Wales. The Tyne valley—or the Tyne gap, as it is often called—is a route between east and west, between the Cheviots and the Pennines. Notice also the Eden lowland in the west, driven like a wedge between the Pennines and the Cumbrian mountains of Cumberland and Westmorland, and its importance as a route. The lowland of York, east of the Pennines, is drained by the Ouse and its tributaries, one of which, the Aire, divides the Northern from the Southern Pennines. The Aire gap, like the Tyne gap, is all important as a route between the lowlands east and west of the Pennines. West of the Southern Pennines, the Cheshire plain between the Pennines and the Welsh mountains opens from the central plain to the Irish Sea exactly opposite the Midland Plain of Ireland. It is consequently the most direct route between the capital of England and the capital of Ireland. Wales has a coastal lowland continuous with the Cheshire plain, narrow in the north and west, but broadening out in the south along the northern shores of the Bristol Channel. Towns and routes in Wales are chiefly in this coastal lowland and the valleys opening to it. The southern lowland of Wales opens by the Severn valley to the plain of England, the northern part of which is drained by the Trent, flowing to the Humber, and by a number of rivers flowing to the Wash, of which the Great Ouse may be noted. The southern portion of the plain, which is broken by numerous heights, is drained by the Thames and its tributaries, and by smaller rivers flowing to the North Sea and the English Channel.

The Lowlands of Ireland. In Ireland the Midland Plain is the chief lowland, running east and west across the country. The other lowlands run for the most part north and south, following the direction of the rivers. In the north the lowlands of the Foyle and Erne separate the mountains of Donegal and Sligo on the west from the central heights. Further east, between these and the Antrim and Mourne mountains, are the lowlands drained by the Blackwater and the Bann. In the west the Shannon, a river of the plain, cuts its way between the mountains of Tipperary and those of Galway and Clare, much as the Thames has done across the chalk heights of southern England. Look out in the map the lowlands of the Blackwater, east of the Kerry mountains of southern Ireland, the extensive lowlands drained by the Barrow and its tributaries, which separate the central heights of southern Ireland from the Wicklow mountains, and the lowlands south of these, drained by the Slaney.

Climate of the British Isles. Our climate is greatly influenced by the proximity of all parts of our islands to the sea, a circumstance which makes our winters mild and our summers cool. The average, or mean annual temperature of the lowlands of England and Ireland is over 48° F., while in the Lower Thames valley, round the south coast of England, and in the lowlands of Cornwall and Devon, it is over 50° F. The January and July isotherms—*i.e.*, lines connecting places of the same average temperature in summer and winter respectively—remind us in many ways of the corresponding isotherms for the Continent [68]. In January the lines run, on the whole, north and south, independently, that is, of the lines of latitude; in July they run, on the whole, east and west.

Winter Temperature. Taking the British isotherms for January, we notice at once the remarkable differences between east and west. The line for 44° F. cuts the extreme west of Southern Ireland and Cornwall. These parts of our islands are 6° warmer in winter than the coldest parts of the east coast of Great Britain. The line for 42° is, on the whole, parallel, but it takes an upward bend over the St. George's Channel, for the sea is warmer than the land in winter. The rest of Ireland has a temperature of 40°, but in Great Britain the only parts which are equally warm are the extreme west of Scotland, Wales, and that small part of England which lies west of a line drawn from the head of the Bristol Channel to Southampton Water. The rest of Great Britain has a January temperature of under 40°. The coldest parts everywhere when height is left out of account, are all in the east, with a temperature of 38° or under. Notice that the eastern counties, from the Humber to the Thames, are as cold as the counties round the Moray Firth, although they are much further south. The extreme north-west of Scotland is warmer than the extreme south-east of England. This shows that the distribution of winter temperature is largely independent of latitude. The all-important factor is the prevalence of westerly or south-westerly winds, which have been warmed by passing over the surface of the Atlantic Ocean. They reach our western shores as warm winds, but as they pass east over the land they gradually become cooled by contact with its cold surface. Hence the eastern parts of our islands are markedly colder than the west.

Summer Temperature. In summer the case is reversed. The Lower Thames basin, which was one of the coldest regions in January, is the hottest part of Britain in July, with a temperature of 64°. The rest of the English plain, except round the coast, has a temperature of 62°. The line for 60° includes the south-eastern corner of Ireland, the whole of Wales, and most of northern England. The line of 58° almost coincides with the north coast of Ireland, and follows the west coast of Scotland for a considerable distance, curving gradually inland to the east coast near Aberdeen. North of this line the lines for 56° and 55° are nearly parallel to each other. Only the Orkneys and Shetlands have a summer temperature below 55° F. In summer, therefore, the east is hotter than the west, but the south is hotter than the north. The relative coolness of the west is, of course, explained by the influence of the Atlantic winds, but we see that their influence is much less marked than in winter, when they blow more strongly and steadily.



68. CLIMATE OF GREAT BRITAIN: RAINFALL, ISOTHERMS, AND ISOBARS
The darker the tint, the heavier the rainfall

Advantages of the British Climate. Our great climatic advantage is our mild winter. Britain lies far west of the isotherm of 32° F., the freezing point. Even in the coldest parts of our islands protracted frosts seldom occur, and the check to vegetation is not very considerable. Our ports are ice-free all the year round, as are our inland waterways. Our summers, though never oppressively hot, are warm enough—except in the extreme north—to bring wheat and many fruits to perfection.

Distribution of Rain. The proximity of the Atlantic influences our rainfall no less than our summer heat and our winter cold. The winds which blow from that ocean—and they blow on an average for two out of three days—are loaded with moisture when they reach our western shores. As they blow all the year round, we have rain all the year round; but they are strongest and steadiest in winter, which is our wettest season. As we should expect, the west is wetter than the east. Had the highlands of Britain lain to the east instead of to the west, the difference in the rainfall of east and west would have been much less marked than at present. As it is, the highlands lie full in the track of the rainy winds, which part with most of their moisture on the windward slopes. The wettest parts of the British Isles are the Connemara and Kerry mountains in the West of Ireland, which have over 60 in. of rain in a year, the highlands of Scotland, and the mountains of Cumberland, Wales, and Cornwall. The plain of England has a rainfall of under 30 in.

It is interesting to compare the rainfall map of Britain with the temperature map for July. We see that the regions with the hottest summers are, on the whole, the drier parts of the country, while the wettest districts have the coolest summers. The effect of this on agriculture is very important. If the summers in the English plain were wet, neither cereals, hay, nor fruit would come to perfection. The western highlands intercept just enough of the rain to provide almost ideal agricultural conditions in the eastern lowlands. Had the lowlands lain in the west, Great Britain would have been in the main a pastoral country, with a less dense population than at present.

Storms, Cyclones, and Anticyclones. Destructive storms frequently visit our coasts, especially in autumn and winter. The first sign of their approach is generally the fall of the barometer. This shows a diminution of atmospheric pressure when an area of low pressure, or an atmospheric depression, as it is called, is moving towards our islands. These depressions usually come from the west—very rarely, indeed, from the opposite direction. As the depression moves onward, air is drawn in from all sides from regions of the atmosphere which are at a higher pressure, producing violent gales, blowing from all directions spirally inwards to the centre of the low-pressure area, which itself remains calm. If the depression is a large one, these gales may last for several days, gradually decreasing in violence as pressure is equalised. Such a moving system of winds blowing inwards towards a calm centre is called a *cyclone*. In winter, when the temperature conditions on which the distribution of atmospheric pressure partly depends are most unequal over the Northern Hemisphere, cyclone after cyclone may occur for many weeks. When the track of the centre of the cyclone lies north of our islands, the winds over the British Isles blow from the south or west, and the weather, though wet and stormy, is mild. If the storm centre is moving south of our islands, we are swept by icy gales from the north or east.

In an *anticyclone* the conditions are reversed. The winds then blow outwards from a calm centre of high pressure towards regions of lower pressure. When anticyclones occur in winter our weather is fine, but intensely cold, owing to the loss of heat by radiation in the calm, cloudless nights; on the other hand, when they occur in summer, our weather is calm, warm, and hazy.

Vegetation. Britain lies naturally in the temperate forest area. The whole of the lowlands were once covered with dense forests, composed in the south of oak, elm and beech, mixed with conifers in the north. Traces of this vanished mantle of forest remain in such patches as Epping Forest or the Forest of Dean, and in such names as Ettrick Forest or Sherwood Forest. To-day only about 4 per cent. of Britain is woodland, 50 per cent. is in crops or grass, 30 per cent. is grazing land, and the remainder consists of mountains, water, roads, etc. Agricultural land is found chiefly in England and Wales, of which three-quarters and three-fifths respectively are under cultivation. In Scotland and Ireland only about one-quarter is cultivated, and grazing is much more important, employing one half of the total acreage of both. In England less than one-tenth is grazing land, and in Wales only one-quarter. Taking Great Britain only, and examining these figures, we should conclude that the relation between agricultural and grazing land depends chiefly on the distribution of relief, the lowlands being agricultural, and the highlands pastoral. And this is quite true. It is true, however, largely because the highlands are wetter, as we may see by comparing the figures for Scotland and Ireland, which differ greatly in relief. For the same reason, we find a difference even in the lowlands of England, agriculture being more important in the drier east than in the wetter west.

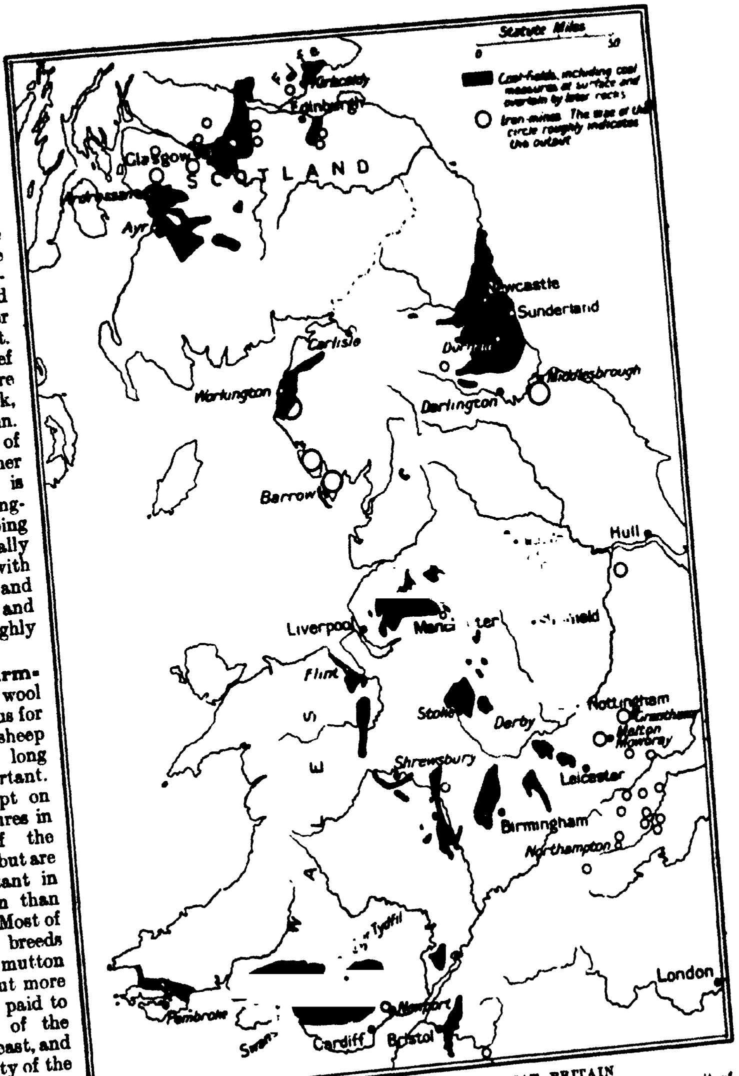
Soils. The distribution of agriculture no doubt depends also on soil, and this again on the character of the underlying rocks. We saw that the highlands of Britain consist of old and very hard rocks, which weather slowly, forming but little soil, most of which rivers carry down to the plains. Where the rocks are softer the soil is much deeper, and of a very mixed character, consisting not merely of the waste of the rocks immediately below, but also of rock-waste of many different kinds brought down by rivers and by the long-vanished glaciers which once covered a great part of our islands. [See GEOLOGY: The "Ice Age."] The local variations are, nevertheless, very great, and every eye detects the difference, for example, between the white soils of the chalk districts of Sussex, or of the limestone districts of Gloucestershire, and the rich red earth of the sandstone districts of South Devon.

Chief Crops. The chief crops are cereals. Wheat and barley are grown in the south-eastern counties, and in the east of the midland plain of Scotland. Oats and barley are grown on the poorer, higher, or more northerly soils. Root crops are cultivated everywhere, but not on the best soils. Potatoes are important in the higher and wetter agricultural districts, and are the staple crop in Ireland. Hops are grown in Worcestershire and the southern counties, those of Kent being specially famous. Fruit is less grown than it should be, especially by the peasantry, who thereby miss a source of profit. Apple orchards and fruit farms are important in the southern counties, particularly in Kent, Devon, and the Severn basin. Flax is grown in the north-east of Ireland, but not so commonly as 30 years ago. Many useful crops, such as the sugar beet, are not grown at all. English agriculture, as a whole, suffers from our land system, the lack of technical education, and the reluctance to adopt the co-operative methods which ensure success in other countries.

The Pasture Lands. These are of two kinds—the moist water meadows of the lowlands of western England and Ireland, which are suitable for the finest breeds of cattle, and the poorer, less succulent pastures of the uplands, or highlands, which are not rich enough for cattle, but suit sheep. Broadly speaking, cattle are fed in the lowlands and sheep on the hills.

Cattle are bred both for beef and for dairy purposes, the latter requiring the richer pasture. The Shorthorn breed is suitable for both purposes. Ayrshire cattle, and the breeds named from Jersey, Guernsey and Alderney are primarily dairy cattle.

In England cattle are most numerous round the western base of the Pennines—in Lancashire, Cheshire, and Staffordshire, in Leicestershire, in the Midlands, in Somerset, Devon (famous for its



69. COAL AND IRON FIELDS OF GREAT BRITAIN

There are workable seams of coal in the carboniferous limestone and millstone grit of Scotland, but these areas are not shown in this map

Devonshire cream), and Cornwall. Pembrokeshire is the chief cattle-raising county in Wales. In Scotland cattle are chiefly bred for beef, and are numerous only in the Midland Plain, large numbers being imported from Ireland to be fattened for the London market. In Ireland the chief grazing counties are Galway, Limerick, Meath, and Dublin. A large quantity of butter and other dairy produce is exported to England. The keeping of pigs is generally associated with dairy farming, and dairy-fed pork and bacon are highly esteemed.

Sheep Farming. English wool has been famous for centuries, and sheep farming has long been important. Sheep are kept on the hill pastures in all parts of the British Isles, but are more important in Great Britain than in Ireland. Most of the good breeds supply both mutton and wool, but more attention is paid to the quality of the wool in the east, and to the quality of the mutton in the west. The chief sheep-farming districts are the chalk downs of England, the Welsh highlands, and the Southern Uplands of Scotland, particularly the Tweed valley. In Ireland most sheep are found in Carlow, Wicklow, and Galway.

Horse Breeding. Horses require better pasture than sheep, and less rich pasture than cattle. They can therefore be kept in districts which are too dry for cattle. Most of the famous breeds belong to the eastern counties—Yorkshire, Norfolk, Suffolk, Cambridge, and Huntingdon. In Scotland the eastern counties of Fife and Linlithgow are the most important. In Ireland, Dublin, Down, Wexford, and Louth breed most horses.

Fisheries. The shallow seas surrounding Britain, and particularly those off the east coasts, are rich in fish. The Dogger Bank, in the North Sea, is one of the richest fishing-grounds in the world, especially for cod and flat fish. The herring fishery is important round the eastern coasts of Britain, following the movements of the herring, which migrate southwards as the year advances. Pilchards are caught in the Cornish waters. The oyster fishery is important off the eastern coast of England.

Minerals and Metals. Many of the rocks which compose the crust of the earth are of use; granite, for instance, is much quarried for building round Aberdeen. The various sandstones and limestones also make good building stones, and limestone is burned for lime. Slates are quarried in the mountains of Wales, Cumberland, and the North of England generally. Some rocks, like those of Caithness, are used for paving; others, like those of Portland, for cement; and new uses are frequently discovered. In recent years a quarry near Oxford has furnished material for a famous polishing soap. In the plains clay is used for making bricks, or, if of sufficiently fine quality, for pottery.

Coal. Of all the products of the earth's crust coal is at present the most valuable. It is used to generate steam for motive power, and our industries depend on a cheap supply of this indispensable fuel. The coal measures lie above the oldest, but below the younger rocks, and can be worked only when some accident brings them near the surface. In parts of the British Isles the crust of the earth has been thrown into waves by the action of internal forces raising the highland regions. In many of these the upper layers of rock have been worn away in the course of ages, leaving the coal measures exposed in places, so that they can be reached by boring through the surface soil. In the Pennines not merely the younger rocks, but the coal measures also have disappeared from the summit. They remain on both flanks, forming the important coalfields of northern England. Coal is similarly exposed round the eastern and southern margin of the Welsh Highlands, and in some parts of the Midlands. Over most of the English plain the coal measures are buried beneath younger rocks, and cannot be worked. In Scotland the coal measures remain in the trough of the midland plain, forming coalfields which extend almost continuously from the Clyde to the Forth. In Ireland the coal measures have disappeared, except in a few isolated patches. Much of the country is covered with peat bogs, which supply the only available fuel.

Iron and Other Minerals. Next in importance to coal is iron, which occurs in many different forms. The purest quality, known as red hematite, is found in the western Pennines. The less pure, brown hematite, is abundant round the margin of the Welsh Highlands, in Northamptonshire, and in Antrim. Other ores are very common in or near the principal coalfields, the most important being the black band ironstone of Scotland and the ores of the Cleveland hills of Yorkshire.

Lead is worked in the Southern Uplands of Scotland, the Pennines, the mountains of Cumberland, Wales, and the Isle of Man, and in the Wicklow mountains of Ireland. Zinc occurs occasionally along with lead; oil shale is common round Edinburgh; salt is mined in Cheshire, Worcestershire, and Durham, and copper and tin are still worked in Cornwall.

Principal Coalfields of Britain. The coalfields of Britain [69] fall into four groups:

A. The Scottish Coalfields:

1. The Ayrshire Coalfield.
2. The Central, or Forth and Clyde Coalfield.
3. The Fife Coalfield.
4. The Midlothian Coalfield.

The chief manufactures on these coalfields are iron, shipbuilding, and textiles.

B. The Pennine Coalfields:

5. The Northumberland and Durham, associated with the iron manufacture in all its branches, including engineering and shipbuilding, and chemicals.
6. The Cumberland Coalfield, associated with iron-smelting.
7. The South Lancashire Coalfield, associated with the cotton manufacture and with iron and chemical industries.
8. The North Staffordshire Coalfield, associated with the pottery industry.
9. The York, Derby, and Nottingham Coalfield—the richest—associated with woollen, iron, and lace manufactures.

C. The Coalfields round the margin of the Welsh Highlands:

10. The North Wales Coalfield, associated with the manufacture of salt and chemicals.
11. The Middle Severn Coalfield, associated with iron, pottery, and woollen manufactures.
12. South Wales and Forest of Dean Coalfield, chiefly engaged in smelting.

D. The coalfields of the Midland Plain, surrounded by younger rocks:

13. The Midland Coalfield, associated with the iron manufacture.
14. The Bristol Coalfield, associated with the woollen manufacture of the West of England.

All these manufactures are more fully treated in the articles on COMMERCIAL GEOGRAPHY.

Continued

continued from page 789

THE TOWN-CLERK

Most Responsible Post in the Municipal Service. Qualifications and Salaries. The Town-clerk's Assistants. Clerks of County Councils

By ERNEST A. CARR

THERE is a marked and increasing tendency among local authorities to restrict applications for the position of town-clerk to members of one or other branch of the law. It is found, indeed, that men thus qualified have gained probably 90 per cent. of the posts recently offered for competition.

What the Town-clerk must Know. The town-clerk's is the foremost position on the municipal staff. He is the adviser to his council on innumerable points of law, fact, and practice—in itself no light office, having regard to the multiplicity of important activities carried on by a progressive borough and the scarcely avoidable ignorance of many of the councillors concerning them. He controls a busy department of his own, and is also the official head of the whole staff and the responsible officer for the due execution of the council's orders. At the meetings of his authority, he is the chairman's right-hand man; and having familiarised himself with the details of every important scheme and proposal—when he has not framed them himself—is in a position to advise upon these as they are raised before the council. The acquirement of property and extension of municipal works, "slum area" clearances, and the adoption of statutory powers—on such grave matters as these his judgment is of great weight. His store of law, routine, and precedents must be always at his finger-tips, as it were, for the services of the various heads of departments who constantly consult him. He must be able to draft new bylaws and regulations as need arises, and to handle adequately his council's case at a Local Government Board inquiry, or before a parliamentary commission. An expert within his own particular province, and a point of focus generally between the council and its staff, the town-clerk needs to blend the qualities of the specialist with those of the tactful and patient administrator.

"Most Difficult Post in the Service." All things considered, the following pronouncement of a municipal expert on the duties of the town-clerk seem amply justified:

"It would be rather invidious to make distinctions between the departments, but as regards the town-clerk's, this, whilst performing functions of its own, generally has a kind of supervision over all other departments, such as communicating the instructions of the council and committees to the various chiefs and seeing that the same are punctually obeyed. Of course, every chief must be an expert in his own line; but, writing as one who has had twenty-one years' experience in city, county borough, and large urban district, I should say the most difficult position to fill in the municipal service is that of the town-clerk."

Nevertheless, this authority frankly avows that if he were about to launch his own son on a municipal career, he would select for him the town-clerk's department in preference to all the rest. The fact is that, with all its responsibilities and worries, the possibilities it offers are greater—and earlier attainable—than any other branch, certain engineering posts alone excepted.

Salaries of Town-clerks. In respect of remuneration, the town-clerk's lot is indeed a happy one. As chief staff officer, he generally enjoys the largest salary on the pay-list. The actual range of payment may be readily illustrated by a few typical appointments, which in some instances include special duties, in addition to those of town-clerk.

The City of London, and such leading corporations as Manchester and Glasgow, pay their town-clerks £2,000 a year. In the London boroughs salaries vary generally between £1,000 and £1,250—that at Wandsworth, for instance, being £1,150. Other figures are as follows, the commencing salary alone being given in certain instances:

Newcastle	£1,500
Leicester	£1,500
Bolton, £650, rising by £50 annually to	£1,000
Burnley .. .. ..£700 to	£900
Bath	£800
Tynemouth .. .. ..£600 to	£800
Rochdale and Wimbledon, each ..	£700
Exeter	£675
Ayr	£500
Ramsgate, £400, rising by £25 annually (with emoluments) to	£600
Bexhill, £300, by £25 annually to ..	£400

Private practice is, in most of these instances, debarred by the terms of the engagement. Where the appointment is not a whole time one, it is almost invariably given to a solicitor, the salaries paid varying from about £100 a year for small district councils, up to £500 or more for the boroughs, and the person appointed having to provide his own offices and staff. High salaries, in this branch of the service at least, are not confined to the foremost authorities, boroughs of quite moderate importance paying their chief official from £700 to £1,000 or so per annum. Such of the posts named as have recently been offered for competition have been usually restricted to admitted solicitors, or, in Scotland, to law agents and Writers to the Signet. The effect of such a proviso is to limit competition, and to render advancement speedy and sure for solicitors of the requisite ability and training.

Qualifications. It will be evident from what has been said of the town-clerk's duties that a wide experience of municipal matters is of even greater importance than a purely legal training. The average solicitor or barrister of ten years' standing, if suddenly translated to the position of town-clerk, would find his padded office-chair a veritable bed of thorns. Local government work has special requirements which can only be met by years of practice in a municipal office. But men thus qualified often win leading appointments at an early age.

The town-clerkship to the City Corporation, for example, which is perhaps the premier position of its kind in the kingdom, is held by a brilliant young lawyer, who when elected was only 35 years old; yet his previous municipal record included several subordinate positions and some seven years' experience as chief of the Leicester staff. The Rochdale appointment was won by a solicitor of 38, who had also held both deputy and principal rank. The town-clerks of Bolton and Bexhill were but 32 when appointed; and the Tynemouth official, having become a deputy town-clerk at the age of 26, and a town-clerk only a year later, gained his present valuable post when only 30 years of age.

The Best Beginning. We have already seen that a number of town-clerkships are held by barristers and by non-lawyers, and there is nothing to prevent town councils from making similar appointments in the future. But they appear to be increasingly reluctant to do so, and a careful study of many successful town-clerks' careers makes it abundantly clear that in order to enter this branch of the service under favourable auspices it is most desirable that a candidate should begin his training as articled clerk to a solicitor holding an appointment as clerk to a local authority. To a considerable extent at least the town-clerk is made rather than born; and the formula for success may be expressed as ability *plus* municipal training *plus* professional qualification. A further argument in favour of the last item in this formula may be found in the practice followed by many minor authorities of combining the appointments of town-clerk and solicitor in one official.

Not a "Close" Calling. The reader must not conclude, however, from what has been said that town-clerkships form a close preserve, as it were, shut off by a ring-fence from those whose circumstances prohibit their becoming articled clerks in their teens. There is too much wholesome competition in the service to permit of this. A number of men have entered the town-clerk's department as paid junior assistants, and on promotion to the grade of committee clerk, or assistant town-clerk, have shown such aptitude for their work that they have been given their articles under the town-clerk or his deputy whilst retaining their salaried posts. In this way the defect of a non-professional start is most readily cured; but its achievement is only possible by the goodwill of the council and their chief officer, and is too uncertain a method to be desirable, if articles can be obtained earlier in the usual way. Moreover, as many an overworked official has discovered to his cost, it is extremely arduous and difficult to prepare for professional examinations whilst occupied all day with the anxieties of a responsible post. Resolute and energetic men, however, are not debarred by these considerations. Recently a busy Midland corporation promoted to the premier position an official of twelve years' standing who had passed through the grades of junior committee clerk and assistant town-clerk, and whose articles, at the time of his appointment as town-clerk had not expired.

Deputy and Assistant Town-clerks. What has been said on the question of training for town-clerkships renders it unnecessary to discuss at any length the grades from which they are mainly recruited. Assistant and deputy rank are the successive steps by which the majority of principals have ascended to their positions. These subordinate posts are often filled by the promotion of able committee and office clerks, for many of whom they represent the highest positions attainable in the absence of a legal training. On the other hand, a solicitor who has served his articles in a municipal office seldom has any difficulty in obtaining as soon as he is admitted either an assistant town-clerkship in an important borough or a deputyship in a smaller one. His salary in either event will probably begin at £150 or £175, and rise to £300 or £350, with or without the right to practise privately. On securing deputy rank under a busy authority these figures may be doubled at least. Thus, Warrington pays its deputy town-clerk £250 a year, Bolton £350, Bradford £500—rising by £25 yearly to £750—and Manchester £1,000. The higher posts, however, are mostly restricted to qualified solicitors. The Bradford appointment mentioned, for instance, is coupled with the duties of assistant solicitor, and was offered under the following conditions:

"Candidates must be thoroughly experienced in local government law and practice, and have an intimate knowledge of the work of a town-clerk's (or equivalent) department in a large district, including conveyancing and common law, and must also be fully competent to act as advocate in conducting important cases before magistrates, etc."

Clerks to the County Councils. Both in value and in the special training expected of candidates, these posts much resemble town-clerkships, but are naturally far fewer in number. They afford a wide gradation of salary, from the £350 paid by the Isle of Wight to the £2,000 with which the County of London rewards its distinguished clerk. It is usual to advertise vacancies inviting applications from solicitors and barristers only. In practice a candidate who was not well trained in the special requirements of county law and administration would have no chance of success. For these, as for the town-clerk's office, the best training is afforded by a deputyship.

Continued

POETRY, FROM MILTON TO COWPER

A Survey of the Chief Works of Milton, Dryden, Pope, Thomson, Gray, Cowper, Burns, and the Minor Poets of the Period

Continued from page 849

By J. A. HAMMERTON

John Milton. The period we are now about to consider is one in which the lessons urged by the critical school of Ben Jonson bore fruit. The greatest name among the poets of the age that witnessed the rise of the Commonwealth and the downfall of the Stuarts is that of the author of "Paradise Lost."

John Milton (b. 1609; d. 1674), "God-gifted organ voice of England," was the son of a scrivener who had been disinherited by his father for changing his faith to that of the Reformers. His early years are thus described in his own words:

"When I was yet a child no childish play
To me was pleasing; all my mind was set
Serious to learn and know, and thence to do
What might be public good; myself I thought
Born to that end, born to promote all truth,
All righteous things."

Though he wrote verses at the age of ten, and paraphrases of the Psalms (including the well-known "Let us with a gladsome mind") as a schoolboy, we find him in the sonnet "On Arriving at the Age of Twenty-three" lamenting his "late spring."

JOHN MILTON

Milton's Early Poems. These were chiefly inspired by the pastoral surroundings of Horton, in Buckinghamshire, where, after leaving Cambridge, Milton spent five years under the parental roof. "L'Allegro" and "Il Penseroso" are mirthful and pensive poems respectively, as their titles imply. In the former occur the familiar lines:

"Quips and cranks and wanton wiles,
Nods and becks and wreathèd smiles."

In the latter is the phrase "the cricket on the hearth" and the oft-quoted reference to

". . . . storied windows, richly dight,
Casting a dim religious light."

"Comus" is a masque, beneath the exquisite allegory of which may be discerned the poet's political bent, and the whole is rich with promise of the work by which its author is most widely known "Lycidas" is an elegiac poem composed in memory of a college friend. It breathes such a contempt for the corrupt holders of ecclesiastical benefices as to make one wonder why it was not made the subject of a Star Chamber "inquiry." Having pondered these poems, the student should read the beautiful lines, "At a solemn music." The works mentioned were composed between the years 1631 and 1637, when, to quote the glowing words of one of the most competent of living critics, Mr. Edmund Gosse, Milton "contributed to English literature about two thousand of the most exquisite, the most perfect, the most consummately executed verses which are to be discovered in the language. This apparition of Milton at Horton," Mr. Gosse goes on to remark, "without associates, without external stimulus, Virtue seeing 'to do what Virtue would by his own radiant light,' this is one of the most extraordinary phenomena which we encounter in our [literary] history."

"Paradise Lost" and "Paradise Regained." The former work is the better, and best known of all his writings. Though owing something, doubtless, to Spenser's "Faëry Queen," it is not only the first English epic; it is unapproached save by Tennyson's "Idylls of the King." There are various forms of this particular class of poetry; its foreign masters are Homer, Vergil, Tasso, Ariosto, and Dante. Milton's original conception was of a drama on the Arthurian legends. Perhaps the Civil War which intervened between the conception and the performance of the work supplied sufficient motive for a theme of a more sublime and solemn character than even those associated with the Round Table. But, as Milton's great editor, Professor Masson, reminds us, Milton inherited, as it were, a subject with which the imagination of Christendom had long been fascinated. "Paradise Lost" is more than the outpouring of a richly-stored mind saturated in the classics and the Bible. It is an epic that has no parallel in our own or in any other language. "It is an epic of the whole human species—an epic of our entire planet, or, indeed, of the entire astronomical universe. The title of the poem, though perhaps the best that could have been chosen, hardly indicates beforehand the full nature or extent of the theme; nor are the opening lines, by themselves, sufficiently descriptive of what is to follow. It is the vast comprehension of the story, both in space and time, that makes it unique among epics, and entitled Milton to speak of it as involving

'Things unattempted yet in prose or rhyme.

It is, in short, a poetical representation, on the authority of hints from the Book of Genesis, of the historical connection between human time and aboriginal or eternal infinity, or between our created world and the immeasurable and inconceivable universe of pre-human existence." Milton's "Ode on the Morning of the Nativity," written in his Cambridge days, conveyed the theory that the pagan gods were fallen angels. "Paradise Lost" deals with the Rebellion in heaven, the Creation, the Temptation, and the Fall. But that Satan is the hero we beg to disbelieve, despite even Professor Masson's dictum. Milton was too full of humanity—witness his twenty years of patriotic service—to idealise the Evil One. It is man himself he sings. Certainly, the deepest interest attaching to both "Paradise Lost" and "Paradise Regained" is inspired by the study of the character of Satan as the tempter of man and the tempter of Christ. But this interest arises from the *object*, or *subject*, of each encounter. The lesson derivable is twofold. On the one hand, we are brought to a consideration of the misuse of a Divinely given freedom; on the other is enforced the conclusion that God is "Grace Abounding" Of "Paradise Lost" Coleridge said that "no one can rise from the perusal of this immortal poem without a deep sense of the grandeur and purity of Milton's soul."

"Samson Agonistes." This was Milton's last work, and is a drama on the Greek model, founded on the Book of Judges, but, as the author expressly states, not designed for the stage. It is the work of one whose cause had been nobly fought for, and hardly lost. The thoughts uttered by Samson came from the heart of the poet who wrote them. The work is severe in style, but derives its highest value from the parallels it offers between the lives of Samson and Milton himself. For our present purpose what we wish especially to emphasise is the importance of the study of Milton's work to all who aspire to the proper and most effective use of their mother tongue. To Milton may be ascribed Spenser's eulogy of Chaucer as "a well of English undefyled." He had, like Achilles, one defect: he had no sense of humour.

Some of Milton's Contemporaries. THOMAS RANDOLPH (b. 1605; d. 1634) need not detain any but the advanced student. EDMUND WALLER (b. 1605; d. 1687) lives as the author of "Go, lovely Rose" and "Lines on a Girdle," lyrics which, as Waller's latest editor, Mr. Thorn Drury, says, "might almost be chosen from English literature to serve as the examples of the charms of simplicity and directness." SIR JOHN SUCKLING (b. 1609; d. 1642) is save . from oblivion by a song, "Why so pale and wan, fond lover?" and a ballad upon a wedding, beginning, "Her feet beneath her petticoat." SIR RICHARD LOVELACE (b. 1618; d. 1658) is the author of a poem, "To Althea, from Prison," the first two lines of the last stanza of which are fairly common property:

"Stone walls do not a prison make,
Nor iron bars a cage"

RICHARD CRASHAW (b. 1613; d. 1649), a transcendentalist, and author of "The Flaming Heart," is responsible for the familiar phrase "That not impossible she." SIR JOHN DENHAM (b. 1615; d. 1669) is the author of a contemplative poem, "Cooper's Hill," which supplies an early model of the rhythmical couplet. ABRAHAM COWLEY (b. 1618; d. 1667) was another of Dryden's predecessors. To-day Cowley is chiefly read for his prose, though, in his own lifetime, he was one of the most popular poets of the day. He belonged to what Johnson called the "metaphysical" school of Donne, of which we have already heard in our Elizabethan studies. Cowley's "Pindaric Odes" prompted the "Alexander's Feast" of Dryden. SAMUEL BUTLER (b. 1612; d. 1680), in his inimitable satiric poem, "Hudibras," which was written in ridicule of the Puritans, displays much learning as well as wit. ANDREW MARVELL (b. 1621; d. 1678) was a friend of Milton, played the part of laureate during the Protector's life, and wrote a "Horatian Ode upon Cromwell's Return from Ireland," which Trench specially commends to English students of Horace. Marvell's lines on the "Emigrants in the Bermudas" are even better known than the Horatian ode. HENRY VAUGHAN (b. 1621; d. 1693) has been aptly styled a "George Herbert in worsted stockings."

John Dryden. We now come to a name secondary in importance to that of Milton only in the period under review. JOHN DRYDEN (b. 1631; d. 1700) is England's greatest satirist in verse. His influence upon his contemporaries was tremendous. His critical deliverances are reverenced to-day. He excelled as a dramatist and as a writer of prose. For the moment, however, we have to concern ourselves with his poems. One of the first of his characteristics that strikes one is his alertness to the significance of events in the world outside of the library. Witness his "Annus Mirabilis" (the "wonderful year" of 1666), wherein he celebrates the English victories over the Dutch at sea and the benefits of the Great Fire of London.

In "Absalom and Achitophel" Dryden directed the whole weight of his powerful intellect to the undoing of the Earl of Shaftesbury's scheme for inducing Charles II. to nominate his illegitimate son the Duke of Monmouth as his successor to the Throne against the lawful claim of the King's brother James, who was a Romanist. At this time, it should be remembered, Dryden, though soon to adopt the Romish faith (see "The Hind and the Panther"), was strongly Protestant, as may be proved by reference to the work that followed "Absalom and Achitophel"—"Religio Laici." Taking as his model the story of Absalom's revolt against David—as Milton had taken his models from the Bible for "Paradise Lost" and "Samson Agonistes"—Dryden named the various parties to the Monmouth plot after the characters in 2 Samuel. The portrait of Shaftesbury, beginning

"In friendship false, implacable in hate,
Resolved to ruin or to rule the State,"

is the most telling example of passionately concentrated poetic portraiture in our literature.

Dryden's Poetic Power. Three other works by Dryden exhibit his splendid lyrical ability—the "Ode to the Memory of Mrs. Anne Killigrew," described by Johnson as "the noblest in our language," the "Song for St. Cecilia's Day," and "Alexander's Feast." Dryden's translations from Homer, Vergil, Ovid, Juvenal, and Boccaccio, are subjects for advanced study. One of his chief claims to our attention is that directness and masculine vigour of his language which almost any half-dozen lines of his verse would illustrate. "Amid the rickety sentiment looming big through misty phrase which marks so much of modern literature," writes James Russell Lowell, "to read Dryden is as bracing as a north-west wind. He blows the mind clear. In ripeness of mind and bluff heartiness of expression he takes rank with the best. His phrase is always a short cut to his sense. He had beyond most the gift of the right word; and if he does not, like one or two of the Greek masters of song, stir our sympathies by that indefinable aroma, so magical in arousing the subtle associations of the soul, he has this in common with the few great writers that the winged seeds of his thought imbed themselves in the memory, and germinate there."

JOHN DRYDEN

ALEXANDER POPE

WILLIAM COWPER

ROBERT BURNS

The Principal Poets between Dryden and Pope. JOHN OLDHAM (b. 1653; d. 1683), the son of a Nuneaton Nonconformist, was a writer of trenchant satires against the Jesuits. MATTHEW PRIOR (b. 1664; d. 1721) wrote a clever parody of Dryden's "The Hind and the Panther," called "The Country and the City Mouse." His muse, as Hazlitt says, was "a wanton flirt." His poems and lyrics are marked by an easy air of abandonment, but have at least the merit of originality as well as wit. JOSEPH ADDISON (b. 1672; d. 1719) wrote poems and a tragedy, "Cato," which Voltaire greatly admired, but his views on poets—his work, for example, in popularising Milton—and his essays, are the chief things by which he is known to-day.

NICHOLAS ROWE (b. 1674; d. 1718) translated Lucan's "Pharsalia," and wrote the still effective drama of "Jane Shore," but is best remembered as a biographer and editor of Shakespeare.

THOMAS PARNELL (b. 1679; d. 1718), author of "The Hermit" and "The Fairy Tale," aided Pope in his translation of the "Iliad," and wrote an "Elegy to an Old Beauty," of which one line is often quoted:

> "We call it only pretty Fanny's way."

EDWARD YOUNG (b. 1683; d. 1765) was a far from admirable character. His "Night Thoughts" have all the gloom but little of the grandeur of "otherworldliness." JOHN GAY (b. 1685; d. 1732) was the author of several delightful songs. "'Twas when the seas were roaring," "Molly Mog," "Sweet William's Farewell to Black-eyed Susan," are among them.

Alexander Pope (b. 1688; d. 1744). Pope tells us that

> "As yet a child, now yet a fool to fame,
> I lisp'd in numbers, for the numbers came."

Many critics maintain that they came too easily. These are they who hold that Pope's polish is as much a proof of his unpoetic soul as Whitman's ruggedness of his. Pope was obviously influenced by Dryden. But Mr. Gosse insists on Pope's great indebtedness to Boileau. "The French satirist had recommended polish, and no one practised it more thoroughly than Pope did. Boileau discouraged love poetry, and Pope did not seriously attempt it. Boileau paraphrased Horace, and in so doing formulated his own poetical code in 'L'Art Poetique'; Pope did the same in the 'Essay on Criticism.'" Mr. Gosse carries the parallel much further, though this goes far indeed, and English poetry must admit a great debt to the French writer who, at an important moment in its development, inculcated in his English pupil purity and decency of phrase. Pope has a special interest for readers of the SELF-EDUCATOR. The son of a London linen merchant, he was excluded from public school and university by reason of his father's religion; and the result was that he was largely self-taught and self-cultivated.

Pope's Characteristics. What did he do? Much by which we are able to judge his time. "He did, in some not inadequate sense," writes Lowell, "hold the mirror up to Nature.

It was a mirror in a drawing-room, but it gave back a faithful image of society, powdered and rouged, to be sure, and intent on trifles, yet, still, as human in its own way as the heroes of Homer in theirs." His work contains great thoughts. They are for the most part gems not of his own mind but gems reset, admittedly with skill, and therefore of permanent value to those unfamiliar of their origin. He was a poet of infinite descriptive ability and some eloquence, chiefly satirical. Like Byron, he was a cripple; and his affliction affected his outlook on the world. His "Essay on Criticism" was written out in prose before he was twenty years old, and then versified. It has been described as "unquestionably the finest piece of argumentative and reasoning poetry in the English language." Professor Spalding says: "None of his works unites more happily regularity of plan, shrewdness of thought, and beauty of verse." For "beauty" read clarity and vigour. The "Essay" is the one work of Pope's with which the young writer should make himself familiar. Professor Courthope has invited attention to the remarkable analogy presented by the poetical career of Pope to the contemporary change in the English Constitution and the parallel ascendancy of Walpole in politics; and maintains that Pope "gave to the couplet as inherited from Dryden a polish and balance which perfected its capacities of artistic expression, perhaps at the expense of its native vigour." Judged by what he was and what he did, not by what other poets were and by what *they* did, Pope will be found to fill a definite and not undistinguished position in the evolution of English letters as they reflect English life.

Thomson, Gray, and Goldsmith. In the poetry of JAMES THOMSON (b. 1700; d. 1748) is heard an echo of that of Spenser. This echo is characteristic of much of the poetry of the eighteenth century. Thomson affords relief from the works of Pope by singing of Nature sincerely, if in a somewhat affected style. His chief poems are "The Seasons" and "The Castle of Indolence," which prepare the way for the beautiful odes of WILLIAM COLLINS (b. 1721; d. 1759) and the scholarly writings of THOMAS GRAY (b. 1716; d. 1771), whose "Elegy written in a Country Churchyard" (Stoke Poges) did for "the rude forefathers of the hamlet" what Pope accomplished for the fashionable folk of the town. Gray wrote little, but what he wrote was written supremely well. He was a man of leisure and refinement, the son—like Milton—of a scrivener. He drew inspiration from Milton and Dryden, and is one of the harbingers of Wordsworth. Mention may here be made of ROBERT BLAIR (b. 1699; d. 1746), who wrote a sombre poem called "The Grave"; WILLIAM SHENSTONE (b. 1714; d. 1763), whose "Schoolmistress" is a tender tribute to a Leasowes teacher, Sarah Lloyd; MARK AKENSIDE (b. 1721; d. 1770), whose "Pleasures of the Imagination" is a poem too dull and too didactic in character to appeal to the modern reader; and OLIVER GOLDSMITH (b. 1728; d. 1774), a name universally beloved—and, in truth, that of a citizen of no one country, but of the world. Let none apply too scornfully or carelessly the term "bookseller's hack," for Goldsmith—poet of "The Deserted Village," writer of that inimitable novel, "The Vicar of Wakefield," and author of the equally delightful comedy, "She Stoops to Conquer"—was a bookseller's hack. Goldsmith had, in generous measure, the saving grace of humour, with infinite tenderness and graceful delicacy of thought. "No writer in the language," says Professor Masson, "has ever surpassed him, or even equalled him, in that witching-simplicity, that gentle ease of movement, sometimes careless and slipshod, but always in perfect good taste, and often delighting with the subtlest turns and felicities, which critics have admired for a hundred years in the diction of Goldsmith." In some respects he touches the heart of man, and especially of the literary man, more surely even than Charles Lamb does. Ireland, that gave us a Swift, also gave us Oliver Goldsmith. The fact is one to be held perpetually in grateful remembrance.

William Cowper (b. 1731; d. 1800). Cowper makes his appeal to young England in the nursery. Where is the English child who has not treasured the ballad of "John Gilpin"? Cowper missed the sweet influences of a mother's love. He laboured from infancy under the disabilities of a weakly frame, and for a time under the terrible burden of insanity. His first masters were Milton and Cowley; his music was also inspired by the works of Thomson. His initial essays in verse were written under the personal influence of the Rev. John Newton, curate of Olney, in Buckinghamshire, a man of melancholic temperament and a converted slave-trader. Cowper's sad experiences of public school life are reflected in his "Tirocinium; or, a Review of Schools." How his famous didactic poem, "The Task," came to be written makes a charming story of woman's influence. Cowper, cheered by the sympathetic friendship of Lady Austen, had written the ballad of "John Gilpin," after Lady Austen had recounted the legend to him; and she then asked him why he did not try blank verse. "I will," he replied, "if you will give me a subject." "Oh," was the rejoinder, "you can write on any subject. Write on this sofa." This was the germ from which sprang "The Task." Thus succinctly Arnold has indicated Cowper's treatment of Lady Austen's theme: "After having come down to the creation of the sofa, fancy bears him away to his school days [at Westminster], when he roved along Thames' bank till tired, and needed no *sofa* when he returned; then he becomes dreamy, traces his life down the stream of time to the present hour, noting what has made him happy, stilled his nerves, strengthened his health, raised his spirits, or kept them at least from sinking; and finds that it has been ever the free communion with Nature in the country." Many charming descriptive passages are interwoven in all this.

It is in "The Task" that is found the often-quoted line:

"God made the country, and man made
the town."

Cowper's Contemporaries. Among these were James Macpherson (b. 1736; d. 1796), the reputed author of "Ossian"; Charles Churchill (b. 1731; d. 1764), author of the satirical "Prophecy of Famine"; Michael Bruce (b. 1746; d. 1767), who wrote that delightful lyric, "Ode to the Cuckoo"; and Thomas Chatterton (b. 1752; d. 1770), who wrote the "Rowley Forgeries" at the age of sixteen,

"The marvellous boy,
The sleepless soul that perished in his pride!"

Chatterton came to London full of hope and confidence in his extraordinarily precocious powers. He died of starvation and poison in a wretched garret, and was buried in the paupers' pit of Shoe Lane Workhouse.

Robert Burns (b. 1759; d. 1796). Scotland's national bard was a poet of the people, who wrote for the people. It was Professor Blackie who declared on his deathbed, "The Psalms of David and the Songs of Burns—but the Psalmist first." These words, said Lord Rosebery on a memorable occasion at Paisley (1896), contain the secret of many a Scottish character. "To Burns," said Lord Rosebery, "we owe it that we canny, long-headed Scots do not stagnate into prose. His genius and character are the Gulf Stream which prevents our freezing into apathy and material life. . . He never fails us. We rally regularly and constantly to his summons and his shrine. His lute awakens our romance, and charms the sunless spirits of darkness. He is the influence that maintains an abiding glow in our dour character." Burns followed no "master" and founded no "school." He stands alone, and in his own domain is without a rival. For the best interests of literature let the young student study such poems as "The Cotter's Saturday Night," "To Mary in Heaven," "To a Mountain Daisy," "Robert Bruce's Address to His Army," "To a Mouse," "Hallowe'en," "Tam o' Shanter," and "The Jolly Beggars," and leave the story of the poet's life for more mature consideration. From the works named may be gained sufficient insight into the humanity, the humour, the pathos, and the lyrical genius of their author. The songs of Burns must appeal to all. They are rich and rare. "The Banks o' Doon," "Green Grow the Rashes O," "The Birks of Aberfeldy," "John Anderson," "Highland Mary," "My Heart's in the Highlands," "Auld Lang Syne," "For a' That and a' That," "The Lass o' Ballochmyle"—these are part of every Scotsman's birthright. But the poetry of Burns is not only a Scottish possession, it enters into the school courses and plays no insignificant part in the formation of the British character.

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Continued

Group 21
MATHEMATICS
7

Continued from page [illegible]

RATIO AND PROPORTION

Chain Rule. Unitary Method. Proportional Parts. Percentage. Profit and Loss. Examples and Answers

By HERBERT J. ALLPORT, M.A.

105. *The ratio of one quantity to another of the same kind is the number of times the first* [illegible] whole number or a fraction.

Since we use division to find how many times one quantity is contained in another, the ratio of two quantities is expressed thus $\frac{\text{1st Quantity}}{\text{2nd Quantity}}$, or thus, 1st Quantity : 2nd Quantity, the notation in the second case being an abbreviation of 1st Quantity ÷ 2nd Quantity. Hence, we see that to find the ratio of one quantity to another we have simply to express the first as the fraction of the second, exactly as in Art. **92**. The ratio of 3 furlongs to 5 miles is $\frac{3}{40}$, since this is the result we get, on reducing 3 furlongs to the fraction of 5 miles. Evidently, the quantities must be "of the same kind." There is no ratio between 2 tons and 5 sovereigns, for 2 tons cannot be expressed as a fraction of 5 sovereigns.

106. The two quantities which form a ratio are called the *terms* of the ratio. The first term is called the *antecedent*, and the second the [illegible]

Since the numerator and denominator of a fraction may both be multiplied or both divided by the same quantity, it follows that the terms of a ratio may both be multiplied, or both divided by the same quantity without altering the value of the ratio.

107. Four quantities are said to be in *proportion* when the ratio of the first to the second equals the ratio of the third to the fourth.

Example **1**. 2, 3, 12, 18 are in proportion, since $\frac{2}{3} = \frac{12}{18}$.

Example **2**. 7 men, 5 men, 3s. 6d. and 2s. 6d. form a proportion. For the ratio of 7 men to 5 men $= \frac{7}{5}$, and the ratio of 3s. 6d. to 2s. 6d. $= \frac{\text{3s. 6d.}}{\text{2s. 6d.}} = \frac{\text{7 sixpences}}{\text{5 sixpences}} = \frac{7}{5}$.

The proportion is expressed by writing the sign ∷ or the sign = between the two ratios.

Thus, 7 men : 5 men ∷ 3s. 6d : 2s. 6d.
or, 7 men : 5 men = 3s. 6d. : 2s. 6d.

Either expression is read thus: "7 men is to 5 men as 3s. 6d. is to 2s. 6d."

Since the first two terms of a proportion form a ratio, they must be quantities of the same kind. Similarly, the third and fourth terms must be of the same kind.

The first and last terms of a proportion are called the *extremes*, the second and third are called the *means*.

108. In any proportion, the product of the extremes equals the product of the means.

Consider the proportion 21 lb. : 1 cwt. ∷ 1s. : 5s. 4d.

The first ratio is $\frac{\text{21 lb.}}{\text{1 cwt.}} = \frac{21}{112}$. The [illegible] $\frac{\text{1s.}}{\text{5s. 4d.}} = \frac{12}{64}$. The proportion states that $\frac{21}{112} = \frac{12}{64}$.

If we now multiply each of these fractions by 112 × 64, we obtain 21 × 64 = 112 × 12. That is, the product of the extremes equals the product of the means. Any other case can be proved in the same way.

109. The application of proportion to the solution of problems depends entirely on the property just proved; for, by means of it, we can, when we know any three terms of a proportion, find the remaining term.

Example **1**. Find the third term of a proportion in which the first, second, and fourth terms are 7, 11, 77.

The product of the first and last terms = 7 × 77.

Hence, the product of the second and third also = 7 × 77. But the second term is 11.

∴ The third term $= \frac{7 \times 77}{11} = \underline{49\ \textit{Ans.}}$

Example **2**. Find a fourth proportional to 21 yd., 8 yd., 42s.

[illegible] means = 8 × 42.

The first term is 21; therefore the fourth $= \frac{8 \times 42}{21} = 16$; and, since the third term is 42 *shillings* the fourth term = $\underline{\text{16s. } \textit{Ans.}}$

110. We shall now solve one or two problems by the aid of proportion.

Example **1**. If 1 ton 5 cwt. of coal cost £1 11s. 3d., what will be the cost of 3 tons 5 cwt.?

EXPLANATION. We make our "answer" the fourth term of the proportion. Now, the third and fourth terms must be of the same kind (Art. **107**). Hence, since our fourth term is to be a "cost," so also must our third term. We see, then, that £1 11s. 3d. must be taken for our third term. It only remains for us to determine which of the two other terms, viz., 1 ton 5 cwt. and 3 tons 5 cwt., is the first term and which the second. To do this we ask ourselves the question: "Will 3 tons 5 cwt. cost more or less than 1 ton 5 cwt.?" Evidently, it will cost more; so that the answer we are seeking is greater than £1 11s 3d.—*i.e.*, the fourth term is greater than the third. It follows that the second term must be greater than the first. Therefore, we are able to *state* our proportion, thus:

1 ton 5 cwt. : 3 tons 5 cwt. ∷ £1 11s. 3d. : Ans.

We must now reduce the first and second terms to the same denomination (since a *ratio* is a *fraction*, and to express one quantity as a fraction of another we must reduce them to terms of the same unit). The answer is then obtained by multiplying together the second and third terms, and dividing by the first (Art. 109). Since the product of the second and third terms forms the numerator of our answer, and the first term forms the denominator, it is clear that we may cancel common factors of the first and third terms, or of the first and second, but *not* of the second and third.

The work finally appears thus :

1 ton 5 cwt. : 3 tons 5 cwt. : : £1 11 3 : Ans.
20 20 13
$\cancel{25}$ cwt. $\cancel{65}$ cwt. 5)20 6 3
5 13 £4 1 3 *Ans.*

Example **2**. If a certain pasture lasts 56 sheep 24 days, how long will it last 64 sheep ?

Here, the term which is of the same kind as the required answer is 24 days. Put 24 days for the third term. Next, ask the question " Will 64 sheep be able to graze for a longer or shorter period than 56 sheep ? Evidently, since there are *more* sheep, the pasture will last *less* time. The second term must, therefore, be less than the first.

Hence,

64 sheep : 56 sheep : : 24 days : Ans.

$$\therefore \text{ Ans. } \frac{\overset{3}{\cancel{24}} \times \overset{7}{\cancel{56}}}{\underset{8}{\cancel{64}}} \text{ days } \underline{\underline{21 \text{ days.}}}$$

111. Such questions as the above, in which we are given three quantities and required to find a fourth, belong to *Simple* Proportion. We shall now consider questions of a like nature, but having more quantities involved, and thus requiring more than one application of the rule in order to solve them. Such questions belong to *Compound* Proportion.

Example **1**. The carriage of 36 lb. for 45 miles is 6s. 9d. How far will 58 lb. be carried for 14s. 6d. ?

We first consider the following question : " If 36 lb. be carried 45 miles for 6s. 9d., how far will 36 lb. be carried for 14s. 6d. ? " The 36 lb. carried, being the same in each case, cannot affect the question. Therefore, we have 6s. 9d. : 14s. 6d. : : 45 miles : required distance.

$$\text{Hence, this distance} = \frac{45 \times 14\text{s. } 6\text{d.}}{6\text{s. } 9\text{d.}} \text{ miles,}$$

$$= \frac{45 \times 174}{81} \text{ miles.}$$

We next ask, " If 36 lb. be carried $\frac{45 \times 174}{81}$ miles for 14s. 6d. how far will 58 lb. be carried for 14s. 6d." Here, the 14s. 6d. does not affect the question, and we have (since *more* lbs. will be carried a *less* distance),

$$58 \text{ lb. : } 36 \text{ lb. : : } \frac{45 \times 174}{81} \text{ miles : Ans.}$$

$$\therefore \text{ Ans.} = \frac{\overset{5}{\cancel{45}} \times \overset{3}{\cancel{174}} \times \overset{4}{\cancel{36}}}{\cancel{81} \times \cancel{58}} \text{ miles} = \underline{\underline{60 \text{ miles.}}}$$

We see, then, that the given distance, 45 miles, has to be changed in the ratio formed by multiplying together the two ratios $\frac{174}{81}$ and $\frac{36}{58}$.

The ratio formed by multiplying together two or more ratios is called the ratio *compounded* of those ratios.

It may be expressed by writing the separate ratios under one another and bracketing them together.

The above example would then be stated as follows :

$$\left.\begin{array}{l} 6\text{s. } 9\text{d. : } 14\text{s. } 6\text{d.} \\ 58 \text{ lb. : } 36 \text{ lb.} \end{array}\right\} \text{ : : } 45 \text{ miles : Ans.}$$

and the answer is obtained by multiplying the third term by all the second terms, and dividing by all the first terms.

Example **2**. If 25 men dig a trench 210 yd. long, 4 yd. wide, 2 yd. deep in 315 days of 8 hours each, in how many days will 150 men dig a trench 280 yd. long, 3 yd. wide, and 3 yd. deep, working 10 hours a day ?

First, pick out the quantity which is of the same sort as the required answer, *i.e.*, 315 days. This is our third term. We now ask a series of questions, referring always to this 315 days.

(i) If 25 men take 315 days, how long will 150 men take ? Less. Therefore, first ratio is 150 men : 25 men.

(ii) If 210 yd. length takes 315 days, how long will 280 yd. length take ? More. Therefore, second ratio is 210 yd. : 280 yd.

(iii) If 4 yd. width takes 315 days, how long will 3 yd. width take ? Less. Hence, 4 yd. : 3 yd.

(iv) Similarly, considering the depth, we get 2 yd. : 3 yd., and (v) considering length of day, we get 10 hours : 8 hours Hence, our statement is,

$$\left.\begin{array}{rcl} 150 \text{ men} & : & 25 \text{ men} \\ 210 \text{ yd.} & : & 280 \text{ yd.} \\ 4 \text{ yd.} & : & 3 \text{ yd.} \\ 2 \text{ yd.} & : & 3 \text{ yd.} \\ 10 \text{ hr.} & : & 8 \text{ hr.} \end{array}\right\} \text{ : : } 315 \text{ days : Ans.}$$

∴ Required number of days

$$= \frac{\overset{63}{\cancel{315}} \times \cancel{25} \times \overset{4}{\cancel{280}} \times \cancel{3} \times \cancel{3} \times 8}{\underset{\underset{\cancel{2}}{\cancel{6}}}{\cancel{150}} \times \underset{\cancel{3}}{\cancel{210}} \times \cancel{4} \times \cancel{2} \times \underset{\cancel{2}}{\cancel{10}}} \quad \underline{\underline{63 \text{ days } \textit{Ans.}}}$$

CHAIN RULE

112. Suppose we have a series of quantities of different kinds, with a given relation between the first and second, between the second and third, and so on. We find the relation between the first quantity and the last quantity by a method known as *Chain Rule*.

Example 1. If 3 turkeys are worth 5 geese, 4 geese are worth 11 ducks, 3 ducks are worth 4 fowls, and a pair of fowls costs 6 shillings, find the value of a turkey.

Using the sign = to denote " are worth," we have

Required value (in shillings) = 1 turkey.
3 turkeys = 5 geese.
4 geese = 11 ducks.
3 ducks = 4 fowls.
2 fowls = 6 shillings.

Thus, the same denominations (shillings, turkeys, etc.), occur on the left as occur on the right. Therefore, the product of the *numbers* on the left will equal the product of the *numbers* on the right ; from which we obtain

$$\text{Required value} = \frac{1\times5\times11\times\cancel{4}\times\cancel{6}}{3\times\cancel{4}\times\cancel{3}\times\cancel{2}}\text{ shillings}$$

$$= \frac{55}{3} = \underline{18\text{s. }4\text{d. }\textit{Ans.}}$$

Example 2. In a mile race A beats B by 66 yd. B beats C by 80 yd. By how much does A beat C ?

Here, A goes 1760 yd. while B goes 1760 - 66, or 1694 yd. B goes 1760 yd. while C goes 1760 - 80, or 1680 yd.

Arranging the work as in Ex. 1, we have

A's 1760 = B's 1694
B's 1760 = C's 1680
Reqd. C's = A's 1760

$$\therefore\ \text{C goes } \frac{\overset{77}{\cancel{1694}}\times\overset{21}{\cancel{1680}}\times\cancel{1760}}{\underset{22}{\cancel{1760}}\times\cancel{1760}}\text{ yd.} = 1617\text{ yd.}$$

$\therefore$ A beats C by 1760 - 1617 = 143 yd. *Ans.*

UNITARY METHOD

113. All the examples considered in Arts. 110-112 may be solved by the *Unitary Method.* Such a method is neat enough when applied to problems in simple proportion, but is not to be recommended in other cases. We shall, however, work out Example 2 of Art. 110, and Example 1 of Art. 111, to illustrate it.

Example 2, Art. 110. If a certain pasture lasts 56 sheep for 24 days, how long will it last 64 sheep ?

Pasture lasts 56 sheep for 24 days.

$\therefore$ It lasts 1 sheep for 24 × 56 days.

$\therefore$ It lasts 64 sheep for

$$\frac{24\times56}{64}\text{ days} = \underline{21\text{ days }\textit{Ans.}}$$

Example 1, Art. 111. The carriage of 36 lb. for 45 miles is 6s. 9d. How far will 58 lb. be carried for 14s. 6d. ?

For 6s. 9d. 36 lb. is carried 45 miles.

$\therefore$ For 1d. 36 lb. is carried $\frac{45}{81}$ miles.

$\therefore$ For 1d. 1 lb. is carried $\frac{45\times36}{81}$ miles.

$\therefore$ For 14s. 6d. 1 lb. is carried

$$\frac{45\times36\times174}{81}\text{ miles.}$$

$\therefore$ For 14s. 6d. 58 lbs. is carried

$$\frac{45\times36\times174}{81\times58}\text{ miles} = \underline{60\text{ miles }\textit{Ans.}}$$

PROPORTIONAL PARTS

114. It is often required to divide a given quantity into parts proportional to given numbers. The method of working will be understood from the following examples :

Example 1. Divide £8 12s. 6d. into three parts proportional to 2, 3, and 5.

Since 2 + 3 + 5 = 10, it is evident that if we divide the sum of money into 10 equal portions, the three parts required will consist respectively of 2, 3, and 5 of these portions.

Now, £8 12s. 6d. ÷ 10 = 17s. 3d.

$\therefore$ The three parts required are

$$\left.\begin{aligned}17\text{s. }3\text{d.}\times2 &= £1\ 14\text{s. }6\text{d.}\\ 17\text{s. }3\text{d.}\times3 &= £2\ 11\text{s. }9\text{d.}\\ \text{and }17\text{s. }3\text{d.}\times5 &= £4\ \ 6\text{s. }3\text{d.}\end{aligned}\right\}\ \underline{\textit{Ans.}}$$

Example 2. Three men, A, B, and C, rent a field for £24 9s. 2d. A grazes 23 cattle for 17 days, B grazes 27 for 15 days, and C 21 for 18 days. How much of the rent should each pay ?

A's 23 cattle for 17 days require as much as 23 × 17 cattle for 1 day = 391 for 1 day.

Similarly, B uses as much as 27 × 15 = 405 for 1 day.

And C uses as much as 21 × 18 = 378 for 1 day.

The rent should, therefore, be divided in the proportion of 391, 405, and 378.

Now 391 + 405 + 378 = 1174.

Therefore, A should pay

$$\frac{391}{1174}\text{ of £24 9s. 2d.} = 391\times\frac{5870\text{d.}}{1174} = 391\times5\text{d.}$$

$$\left.\begin{aligned}&= £8\ \ 2\text{s. }11\text{d.}\\ \text{B should pay }405\times5\text{d.} &= £8\ \ 8\text{s. }\ 9\text{d.}\\ \text{C should pay }378\times5\text{d.} &= £7\ 17\text{s. }\ 6\text{d.}\end{aligned}\right\}\ \underline{\textit{Ans.}}$$

Example 3. Three boys, A, B, and C, divide 10726 nuts between them. As often as A takes 4, B takes 5, and as often as B takes 3, C takes 7. Find the number each boy has.

A's share : B's share = 4 : 5.
B's share : C's share = 3 : 7.

The numbers representing B's share in the two ratios are 5 and 3. The L.C.M. of 5 and 3 is 15. Therefore, multiply the first ratio by 3 and the second by 5, in order to make B's share be represented by the same number, 15, in each ratio. We thus obtain

A's share : B's : C's = 12 : 15 : 35.

$\therefore$ A has

$$\frac{12}{12+15+35}\text{ of the nuts} = \frac{12}{62}\text{ of }10726$$

$$\left.\begin{aligned}&= 12\times173 = 2076\\ \text{B has }15\times173 &= 2595\\ \text{C has }35\times173 &= 6055\end{aligned}\right\}\ \underline{\textit{Ans.}}$$

EXAMPLES 14

1. A man whose stride is 30 in. takes 3120 steps to go a certain distance. How many steps will a man whose stride is 2 in. longer take to go the same distance ?

2. A garrison of 5000 men has provisions for 137 days. After 50 days it is reinforced by 800 men. How many more days will the provisions now last ?

3. A man contracts to do a piece of work in 48 days, and employs 20 men. He finds, at the end of 36 days, that only half the work is finished. How many extra men must he now engage in order to fulfil the contract ?

4. When candles are 6 to the pound, each candle burns 6 hours. How long will a candle burn when they are 8 to the pound ?

5. In a certain village 2 women in every 5, and 4 men in every 9, are unmarried. There are 24 unmarried women, and the total number of men is to the total number of women in the ratio 3 : 4. Find the number of married men.

6. A cask was filled with wine and water mixed together in the ratio 5 : 3. When 16 gallons of the mixture had been drawn off, and water put in instead, the ratio of wine to water was 3 : 5. How many gallons did the cask hold ?

7. If the carriage of 72 cwt. for 15 miles is £2 5s., how far will 5 cwt. be carried for half-a-crown ?

8. If 4 men or 8 women can plant a field of 5 acres in 3½ days, working 10 hours a day, how long will it take 2 men and 3 women to plant 8 acres working 12 hours a day ?

9. The first of 4 boys can copy 4 pages while the second copies 5, the second does 6 while the third does 7, and the third does 3 while the fourth does 2. How many pages will the fourth boy copy while the first boy does 18 pages ?

10. In a 100 yd. race A beats B by 1 yd. B beats C by 1½ yd. in 120 yd. By how much will A beat C in a mile, supposing A, B, and C to always run at the same rates ?

11. A heap of 126 coins consists of half-crowns, florins, and shillings ; the values of the half-crowns, florins, and shillings are as 2 : 3 : 4. How many shillings are there ?

12. If 100 men can make an embankment 55 yd. long, 20 ft. wide, and 5 ft. high in 4 days, working 11 hours a day, how many will be required to make an embankment 120 yd. long, 25 ft. wide, and 4 ft. high, in 5 days, working 12 hours a day ?

PERCENTAGE

115. The expression "per cent.," which is an abbreviation of the Latin words "per centum," means "for each hundred."

The symbol % is often used to denote "per cent." Thus, 7 per cent., or 7%, means 7 parts out of every 100 parts, *i.e.*, $\frac{7}{100}$ of the whole.

The *number* per cent. is called the *rate* per cent.

116. Clearly, then, a percentage of a given quantity can always be expressed as a vulgar fraction of that quantity. In some cases the corresponding vulgar fractions are so simple that it is advisable to remember them. For example:

$$25\% = \frac{25}{100} = \frac{1}{4}, \qquad 50\% = \frac{50}{100} = \frac{1}{2},$$

$$75\% = \frac{75}{100} = \frac{3}{4}, \qquad 33\tfrac{1}{3}\% = \frac{33\frac{1}{3}}{100} = \frac{1}{3},$$

$$66\tfrac{2}{3}\% = \frac{66\frac{2}{3}}{100} = \frac{2}{3}, \qquad 5\% = \frac{5}{100} = \frac{1}{20},$$

$$2\tfrac{1}{2}\% = \frac{2\frac{1}{2}}{100} = \frac{1}{40}, \qquad 12\tfrac{1}{2}\% = \frac{12\frac{1}{2}}{100} = \frac{1}{8},$$

and so on.

Again, since 5% = $\frac{1}{20}$, 5% of £1 = 1s. Therefore, 5 per cent. of any sum of money is "1s. in the £." Similarly, 2½ per cent. of a sum of money is "6d. in the £."

117. To find any required percentage of a given quantity, express the percentage as a vulgar fraction, and take that fraction of the given quantity.

Example 1. Find the value of 7 per cent. of 35 tons.

7 per cent. = $\frac{7}{100}$.

Hence

$$\begin{array}{r} 35 \text{ tons} \\ 7 \\ \hline 2{\cdot}45 \text{ tons} \\ 20 \\ \hline 9{\cdot}00 \text{ cwt.} \end{array}$$

2 tons 9 cwt. *Ans.*

Conversely, to find what percentage one quantity is of another, reduce the first quantity to the fraction of the second [Art. **92**], and take that fraction of 100.

Example **2.** A tradesman deducts 3s. 6d. from an account for £5 16s. 8d. as "discount for cash." What rate per cent. does he allow ?

$$\text{Required rate per cent.} = \frac{3s.\ 6d.}{£5\ 16s.\ 8d.} \text{ of } 100$$

$$= \frac{42}{1400} \text{ of } 100 = 3\%\ \textit{Ans.}$$

PROFIT AND LOSS

118. When a thing is sold for more than it cost the seller, it is said to be sold at a *profit*. If it is sold for less than the cost, it is sold at a *loss*. Hence,

Profit = Selling Price − Cost Price.
Loss = Cost Price − Selling Price.

A profit, or loss, is generally reckoned as a percentage.

It is always understood that *the percentage is reckoned on the cost price.*

Thus, if an article which costs 9d. is sold for 1s., the seller gains 3d. on an outlay of 9d., *i.e.*, he gains $\frac{3}{9}$, or $\frac{1}{3}$ of his outlay. His gain per cent. is, therefore, $\frac{1}{3}$ of 100, or 33⅓ per cent.

A common mistake is to say that he gains 3d. on 1s., *i.e.*, $\frac{1}{4}$ of 100 per cent., or 25 per cent.

119. The types of questions met with in Profit and Loss, and the methods of solving them, will be understood from the following examples:

Example 1. A merchant buys 56 gallons of wine for £58 6s. 8d., and sells it at 21s. 8d. a gallon. What is his gain or loss per cent. ?

$$\text{He buys 1 gallon for } \frac{£58\ 6s.\ 8d.}{56} = £1\ 0s.\ 10d.$$

He sells 1 gallon for £1 1s. 8d.

Therefore, he gains £1 1s 8d. − £1 0s. 10d., *i.e.*, 10d., on an outlay of £1 0s. 10d., or 250d.

His gain per cent. is, therefore,

$$\frac{10}{250} \text{ of } 100 = 4\%\ \textit{Ans.}$$

Example 2. A watch was sold for £8 11s. at a loss of 5 per cent. What would have been the gain or loss per cent. had it been sold for 10 guineas ?

The watch is sold for 95 per cent. of its cost. We have, then, a question in simple proportion, viz., "If £8 11s. represents 95 per cent. of the cost, how much per cent. of the cost does £10 10s. represent ?" Whence,

£8 11s. : £10 10s. :: 95% of cost : required percentage.

$$\therefore \text{ Ten guineas represents } \frac{\overset{5}{\cancel{95}} \times \overset{70}{\cancel{210}}}{\underset{\underset{3}{\cancel{9}}}{\cancel{171}}} \text{ per cent. of cost}$$

$= \frac{350}{3} = 116\frac{2}{3}$ per cent. of cost, *i.e.*, there is a *gain* of 16 % *Ans.*

Note that in questions like Ex. 2 it is not necessary to find the cost price.

Example 3. **A jeweller prices a brooch 40 per cent. above cost. He deducts 12½ per cent. for cash, and gains 9s. What did the brooch cost him ?**

A brooch which costs 100 is marked 140, *i.e.*, it is marked at $\frac{140}{100}$, or $\frac{7}{5}$ of its cost.

The jeweller deducts $\frac{12\frac{1}{2}}{100}$ of its marked price, so that he sells it for $\frac{87\frac{1}{2}}{100}$, or $\frac{7}{8}$ of its marked price.

But $\frac{7}{8}$ of marked price = $\frac{7}{8}$ of $\frac{7}{5}$ of cost = $\frac{49}{40}$ of cost = $(1 + \frac{9}{40})$ of cost.

He therefore gains $\frac{9}{40}$ of what it cost him.

Hence, 9s. = $\frac{9}{40}$ of cost.

Therefore, cost = 40s. = £2 *Ans.*

Example 4. If 2½ per cent. more is gained by selling a horse for £75 than by selling it for £73 10s., what did the horse cost ?

The difference in the selling prices = £75 − £73 10s. = £1 10s.

Therefore £1 10s. *is* 2½ *per cent. of the cost price, i.e.*, $\frac{1}{40}$ of the cost price.

Hence, cost price = 40 × £1 10s. = £60 *Ans.*

Example 5. A man sells an article at a profit of 5 per cent. Had he bought it 6¼ per cent. cheaper and sold it for 9d. more than he did, he would have gained 15 per cent. Find the cost price.

If he bought for 6¼ per cent. less, he would pay $\frac{93\frac{3}{4}}{100}$ of what he actually does pay.

To gain 15 per cent. he must sell for $\frac{115}{100}$ of the cost, *i.e.*, he must sell for $\frac{115}{100} \times \frac{93\frac{3}{4}}{100}$ of the actual cost.

$$\frac{\overset{23}{\cancel{115}}}{\underset{\underset{4}{\cancel{20}}}{\cancel{100}}} \times \frac{\overset{\overset{3}{\cancel{15}}}{\cancel{375}}}{\underset{16}{\cancel{400}}} = \frac{69}{64} \text{ of actual cost.}$$

But he really sells to gain 5 per cent., *i.e.*, for $\frac{105}{100}$, or $\frac{21}{20}$ of the cost price. The difference between these selling prices is $(\frac{69}{64} - \frac{21}{20})$ of the cost price, or $\frac{345 - 336}{320} = \frac{9}{320}$ of cost price.

And the question tells us the difference in the selling prices is 9d. Hence, 9d. = $\frac{9}{320}$ of cost price, so that the cost price = 320d. = £1 6s. 8d. *Ans.*

EXAMPLES 15

1. By selling goods for £247 a merchant loses 5 per cent. What ought the selling price to be to gain 7 per cent. ?
2. A man buys a number of oranges at 2 a 1d. and an equal number at 3 for 2d. He sells the whole at 5 for 3d. Find his gain or loss per cent.
3. If 4 per cent. more is lost by selling an article for 9s. 2d. than by selling it for 9s. 7d., how much per cent. is lost in each case ?
4. A shopkeeper bought 750 eggs at 15 a shilling. He broke 13, and after selling the remainder, found that he had lost 2% on his outlay. How many did he sell for a shilling ?
5. 24 lb. of tea worth 1s. 10d. per lb. are mixed with 8 lb. worth 2s. 10d. per lb. At what price per lb. must the mixture be sold in order to make a profit of 10 per cent. ?
6. A man sold a house at a profit of 10 per cent. Had he sold it for £168 less, and bought it 5 per cent. cheaper, he would have gained 4 per cent. For what amount did he sell the house ?
7. A tradesman marks his goods 20 per cent. above cost price, but allows a discount of 7½ per cent. off the marked price. What is his net gain per cent. ?
8. A man sold two houses for £990 each. He gained 10 per cent. on the one, and lost 10 per cent. on the other. Find the amount he gains or loses on the whole transaction.

Answers to Arithmetic

EXAMPLES 12

1. $14{\cdot}096\dot{2}5944\dot{1}$.

2. $21{\cdot}9\dot{2}3\dot{6} - 9{\cdot}\dot{3}89\dot{3} = 12{\cdot}53\dot{4}29\dot{7}$.

3. $2{\cdot}25\dot{2}8571\dot{4} = 2{\cdot}25 + {\cdot}00\dot{2}8571\dot{4} = 2\frac{1}{4} + \frac{2}{700} = 2\frac{44}{175}$.

4. Reduce both sums to halfpence. Then, required fraction = 7527 ÷ 47671 = $\frac{3}{19}$ = $\cdot\dot{1}5789473684210526\dot{3}$. (Apply Art. **96** (3) to obtain the last nine digits of the period.)

5. $\cdot1\dot{3}\dot{6}$ of £7 14s. 11d − $\cdot0\dot{2}\dot{4}$ of £6 0s. 3¾d. = $\frac{3}{22}$ of £7 14s. 11d. − $\frac{7}{275}$ of £6 0s. 3¾d. = £1 1s. 1½d. − 3s. 0¾d. = 18s. 0¾d.

6. $\cdot7\dot{3}$ of $1{\cdot}\dot{2}3\dot{4}$ of 12 = $\frac{11}{15}$ of $14{\cdot}8\dot{1}\dot{0}$ = 11 × $\cdot9\dot{8}7\dot{3}$ = $10{\cdot}8\dot{6}1\dot{2}$.

7. $\frac{2}{7} = \cdot\dot{2}8571\dot{4}$; $\frac{1}{7} = \cdot\dot{1}4285\dot{7}$; $\frac{3}{7} = \cdot\dot{4}2857\dot{1}$; $\frac{4}{7} = \cdot\dot{5}7142\dot{8}$; $\frac{6}{7} = \cdot\dot{8}5714\dot{2}$; $\frac{5}{7} = \cdot\dot{7}1428\dot{5}$. Write the decimals under one another in this order.

8. $\cdot13\dot{6} = \frac{123}{900}$. $\cdot\dot{8}\dot{2} = \frac{82}{99}$. Reduce these fractions to their least common denominator, obtaining $\frac{1353}{9900}$ and $\frac{8200}{9900}$. The required greatest divisor will have 9900 denominator, and the H.C.F. of 1353 and 8200 for numerator.

$$\therefore \text{ Ans.} = \frac{41}{9900} = {\cdot}00\dot{4}\dot{1}$$

9. $\cdot\dot{8}\dot{1} = \frac{81}{99} = \frac{9}{11}$. Hence, the rent of each floor is $\frac{11}{9}$ of the rent of the floor above. ∴ ground floor rent = $\frac{11}{9} \times \frac{11}{9} \times$ £51 6s. = £76 12s. 8d.

10. $\cdot\dot{3}8461\dot{5} = \frac{5}{13}$. Hence, $(1 - \frac{5}{13} - \frac{1}{4})$ of the original number is 57. Or 57 passengers = $\frac{19}{52}$ of the original number

$$\therefore \text{ Original number} = \frac{52}{19} \times 57 = 156.$$

EXAMPLES 13

1. £48487 5s. 4d.
2. £2357 3s. 11½d.
3. £23 14s. 6$\frac{6}{19}$d.
4. £537 9s. 9½d.
5. £99 3s. 8d.
6. £117 4s. 2$\frac{3}{16}$d.
7. £23 2s.
8. £427 9s. 10$\frac{4}{11}$d.
9. £52 7s. 6$\frac{3}{16}$d.
10. £8004 13s. 1½d.

Continued

GROOM, GARDENER & COOK

Work of the Groom, Stable Hands and Gardener. Qualifications and Duties of Cook and Kitchenmaid

Continued from Page 816

By A. EUNICE T. BIGGS

THE GROOM

The chief duty of a groom is to look after the horses, and to see they are in condition. His work in the stables will occupy most of his time, but in some households, where the total number of servants kept is not very large, he may be expected to perform certain indoor duties as well. He will probably be required to ride with his master or the ladies of the family. These, however, are purely subsidiary duties, his chief work being in connection with the horses under his care. When they are not working regularly they will need to be exercised each day, and a good groom will see that the exercise is suitable for each individual animal.

Feeding and Watering the Horses. These duties will fall to the share of the groom. He will have to supervise, and in many cases carry out, the feeding of the horses. Each horse will need three meals a day, the amount and character of the food varying with the work it is called upon to perform. The groom must be an early riser, for at 6 a.m. or earlier he will have to set about the preparation of the first meal. The food should, as a rule, be given before the horses drink. Care should be taken to procure pure water, which is improved by the addition of oatmeal. The water should not be too cold.

The groom should be on the alert to see that the shoes of his horses are in good condition. After shoeing, especial care should be given to the feet, and it is as well not to attempt much work immediately after a horse has been re-shod. Every day, after exercise, the horses' feet should be washed in water and then well dried with a brush. When the bit is removed it should be at once washed, dried, and polished. All the metal-work of the harness should be well polished, and the leather wiped over and cleaned. The harness should then be hung up in the harness-room on specially provided pegs. No harness should be left lying about, and the room ought to be well ventilated and free from damp.

THE STABLE HANDS

The cleaning of the stables is in the hands of the stablemen. Each day the stables should be thoroughly swept, and then washed, buckets of water and stiff brooms being necessary for the process. If this is in any way neglected the results are very disastrous to the freshness and neatness of the stable. Fresh straw should be placed under the horses directly it is needed.

The stable hands will assist with the care of the horses. The daily grooming takes some time; each horse has to be brushed over every part of the body, care being taken to follow the direction of the growth of the coat. If the horse is splashed with mud or stained, it may need special brushing with a brush dipped in water. Then the body is rubbed over with a cloth. Both mane and tail have to be well combed; they may also need trimming, and a little oil may be used to get a smooth, glossy effect.

Cleaning the Carriages. The carriage should be freed from mud before it hardens and dries. Plenty of water should be thrown over it, and a mop used to clean every crevice.

By means of a jack each wheel is in turn raised and left free to rotate. Then the wheels also are washed free from mud. The whole exterior must be thoroughly dried, and when it is quite dry it must be well polished with a leather. Sweet oil is used to remove stains, and also to preserve the varnish from cracks and blisters.

The brasswork, handles, etc., must be thoroughly polished with paste and leather. The carriage cushions should be taken out, beaten and brushed, and then replaced. The whole of the interior should be brushed and dusted, the foot-rug taken out and shaken, and the window-glass cleaned and polished. These duties may devolve on any of the men connected with the stables, from coachman downwards, but he is himself responsible for the work, and before taking the carriage out he should see that it is satisfactory in every way. If the springs get worn, the hinges of the door creak, or other minor repairs become necessary, he should be on the alert to detect these defects and see that they are remedied.

THE GARDENER

The gardener's duties will vary considerably, according to the area of the land for which he is responsible, and the number of under-gardeners and odd men whose services are at his disposal

In a large estate the head-gardener will probably be allotted a small house, which privilege is also enjoyed by the coachman. His duties will, to a large extent, consist of organising the work of the men under him. He will consult with the master as to the laying out of different parts of the garden, as to possible changes in its form and arrangement, and concerning the adornment of particular parts. He will be responsible for the supply of fruit and vegetables to the house. One of his privileges is a free supply of such food to his own table; he is also justified in receiving certain commissions from seed merchants, provided that he has always his master's interest at heart, and that he does not order from a particular firm merely to secure a large commission.

The head-gardener will have to see that the various products of the gardens, seeds, cuttings, etc., are properly collected and used to advantage. He will do little of the actual work himself, but he must be quick to detect which of his assistants excels in any particular kind of work, and allow him to do that work whenever possible. A man may be very deft in one direction and equally clumsy in another, and the head-gardener should see that each man's talents are made the most of in allotting the various tasks.

THE COOK

The cook is the chief of the servants who take their meals in the servants' hall. If she is working in a small establishment, many duties will fall to her share which in a larger house would have been relegated to other servants. Should she share the household duties with only one or two other servants, her own duties will include the care of various rooms besides her kitchens, and she may, by arrangement prior to her engagement, be called upon to assist with work outside her own particular domain.

It is of great importance that the cook should be an early riser. Unless many apparently trivial duties are performed before breakfast, the work after that meal tends to become disorganised and laborious. The cook should be up in good time, or she will find it none too easy a task to prepare the breakfast, and see that all is in readiness at the appointed hour. A punctual cook adds much to the comfort of the household. Her energy is a good example to her fellow-servants, and the various members of the family will be incited to more punctual habits if each meal is on the table at a fixed hour.

Characteristics of a Good Cook. A good cook will not only be careful to serve the meals at their proper time, but she will take great pains to ensure the food being well prepared and thoroughly cooked. She will not undertake the preparation of more elaborate dishes than she has the experience and skill to execute satisfactorily. She will do her utmost to serve every dish tastefully, and to prepare the food so that it is appetising and digestible.

A good cook is economical in her treatment of food. No scraps are wasted, and she will arrange that food is not allowed to get stale or turn sour. To secure this end it is important that she should examine her larder every day. Provisions that are put away for a second meal should be placed in clean dishes. Soups and liquid foods will probably need to be warmed up and replaced in clean tureens, and it is important that the interior of the bread-pan be frequently wiped out with a clean cloth.

The cook should daily go through her household supplies to see that no important article is missing. Unless this precaution is taken it is very likely that she will suddenly find herself at a loss for lack of mustard, or some other essential ingredient. Flavouring substances, spices, vinegar and similar articles should be added to the store-cupboard before the previous stock is quite exhausted.

The cook should keep a slate in some accessible corner of the kitchen, on which to record any deficiency directly she notice it. Then, when she receives her orders for the day, either from her mistress or from the housekeeper, she can refer to this in stating her wants. If she trusts entirely to her memory, she will probably find it fail her in some important particular.

The Cook's Dress. Neatness should be the keynote of a cook's attire. Her work necessitates long hours in the warm atmosphere of a kitchen, and she will find cotton or print dresses the most serviceable and durable.

The skirt, which should be short enough to clear the ground, should be covered with a large apron provided with a bib. Many cooks wear two aprons—a small neat one, and a larger one which practically covers the whole skirt. This upper apron protects the one underneath, and can be quickly removed should the cook need, say, to answer the door.

Comfortable, well-fitting shoes with fairly thick soles are essential, as constant standing is very trying to the feet.

Kitchen Arrangements. If the kitchen routine is to proceed without a hitch, the cook must be methodical and orderly in all she does. It is a great mistake to allow utensils to accumulate on the tables whilst cooking is in progress. As each basin, jug, or spoon is done with, it should be put aside to be washed later. Articles that have been taken from the store-cupboard, such as currants and flour, should be replaced as soon as they have been used. The cook only hinders her own operations by allowing the table to become strewn with utensils.

The daily duties of the cook will depend to a very large degree on the size of the family and the number of the servants. If but few of the latter are kept, the cook's duties will depend, to a certain extent, upon the arrangment made between herself and her mistress when she was engaged. She should be downstairs early, clean her kitchen range, light the fire, and put on the kettle. She should then proceed to the breakfast-room, which will probably be under her special care. This room will need careful sweeping, dusting, and rearranging. She should then lay the breakfast and put everything in readiness for the meal.

Duties. In some houses all this work in the dining and breakfast-room is done by the housemaid. In this case, after her preliminary kitchen duties, the cook can at once proceed to the hall and staircase. She should remove the mats, shake and replace them, brush the stair-carpet, rub up the rods, and dust each side of the "tread," and also the banisters. If the hall is tiled or covered with linoleum, it will need either washing or wiping over daily.

The cook will then return to her kitchen, sweep and dust it, and make it neat and comfortable before she sets about the preparation of breakfast. Sometimes the cook is responsible for the waiting at table during breakfast if the only other servant is a housemaid. In any case, she, as a rule, clears away after the meal. Whilst the family are at breakfast, the cook generally helps the housemaid to make the beds.

Having removed the breakfast things, the cook washes them up, with the exception of the plate and glass, which is left to the housemaid. Then she should tidy up her kitchen, and by 10 o'clock be in readiness for the visit of the mistress or the housekeeper.

The Preparation of Meals and Menus. The cook may sometimes be expected to suggest a menu for the day's lunch and dinner, or she may have to await instructions. If there are any deficiencies in the stores to be made up, she should then report them, at the same time drawing her mistress's attention to any particular food which should be consumed at once.

After the orders for the day have been received, the cook will find the morning occupied with culinary matters. Many orders will have to be given to the various tradespeople. The cook should see that her mistress is well served, that vegetables are sent fresh from the greengrocer, and that full measure is given.

During the morning the cook should prepare luncheon, and also make ready all that she can for the dinner. Cold sweets can be prepared, and the greater part of the preparation of many dishes may be arranged. When the actual time of dinner draws near, the cook should endeavour to so organise her work that there is no hurry or confusion at the last minute.

Among her further duties will be included the cleaning of the larder and of the scullery, if no scullerymaid is kept. The sinks should be flushed periodically with boiling water to which a little soda has been added. Greasy, soapy water has a tendency to clog the outlet pipes, as the water cools and the grease solidifies. This can be remedied by the use of very hot water every now and then. Certain other tasks, such as the washing and whitening of the front steps, may fall to her share in a small household, and she may, by arrangement, be asked to assist in doing a little laundry work.

THE KITCHENMAID

The kitchen, or scullery maid does the dirtier part of the kitchen work, leaving the cook more freedom to pursue her culinary duties. If both kitchen and scullery maid are kept, the actual cleaning and the washing of saucepans and other utensils falls to the lot of the latter. The kitchenmaid prepares the vegetables for table, and undertakes the less skilled cooking. She relieves the cook of most of her household duties, such as the scrubbing of steps and washing the hall, etc.

In a large establishment, working under a good cook, the kitchenmaid may acquire an excellent knowledge of cooking. This, however, will almost entirely depend upon her superior in the kitchen. Some cooks resent the idea of allowing their kitchenmaids to become proficent, and will banish them to other tasks in the scullery while the more interesting work is going on. The kitchenmaid will probably be entirely responsible for the preparation and serving of her fellow-servants' meals

Hints for the Scullerymaid. Plenty of boiling water should be used in washing up dirty kitchen utensils. The washing-up bowls should be washed out with strong soda-water after use, and then wiped dry. Dishes and plates should be rinsed in clean water after washing, and be put to dry in a specially constructed rack.

Much labour will be saved in the cleaning of baking-tins and saucepans if they are put to soak in hot soda-water as soon as they have been used, and all copper and tin utensils should be polished at least once a week.

No cooking utensils should be left dirty from one day to the next. After the saucepans have been cleaned, they should be carefully dried; pastry-boards and rollers should be scrubbed, and the kitchen table also kept scrupulously clean. The cleaning of the knives and the brushing of the gentlemen's boots will fall to the share of the scullerymaid. However, as is the case with each domestic servant, the exact duties of the kitchenmaid can hardly be defined. They vary in different households, and the requirements and individual wishes of each particular cook determine whether the position of kitchenmaid is altogether desirable and pleasant.

THE HOUSEMAID

The housemaid should possess a love of order and of punctuality. She should be neat and methodical in her work, an early riser, and if she is skilful with her needle she will be able to add much to her mistress's comfort. In a large establishment the duties of the housemaids will vary with the number kept and also with the number of other servants included in the household. The upper-housemaid will have only very light duties to perform, but her responsibilities will be fairly heavy, for she will have to superintend the work of the other housemaids, and see that every detail of it is carried out thoroughly.

The drawing-room will be under her particular care. She may undertake its sole charge, doing all the sweeping and dusting herself; or she may prepare the room for sweeping, and after this has been done by an under-housemaid, she herself may dust and polish.

The Duties of the Housemaid. Where several housemaids are kept, the various duties will be divided among them, but the daily tasks of each will be, to a great extent, similar. Certain rooms will be entrusted to the housemaid, which she will have to arrange before breakfast. She will have to open the shutters and windows to air the rooms, tidy the hearths and lay the fires, sweep the carpets and rugs, and then very carefully dust the whole room. When the housemaid is down in good time she will be able to do all this work before beginning her duties upstairs. If there is no lady's-maid, she must, at the appointed hour, call the members of the family, taking hot water to each room. If the mistress takes a cup of early tea, the housemaid must take this up also. She will then come down to her own breakfast, and when that is finished she will set the breakfast of the household in readiness. In the case of this work being undertaken by the cook, the housemaid will find plenty to occupy her until the family are assembled for breakfast. During that meal she will repair to the bed-rooms and strip the beds for airing. Her next duty is to empty the baths, arrange the washstands, and put fresh water in the water-bottles and jugs.

Bedmaking. The process of bedmaking is next begun. Each bed, after a good airing, is made to suit the individual taste of its occupant. The housemaid will probably be given some assistance in bedmaking, either by the cook in a small household, or by another housemaid in a larger establishment. The sheets should be arranged smoothly and well tucked in, the pillows and bolsters beaten up and shaken so that they are soft and comfortable. Some mattresses will need to be turned and shaken daily, and in the case of a feather bed this is absolutely essential.

When the beds have been made, the bed-rooms will need to be cleaned. The carpets should be gone over with a dustpan and brush and the skirtings dusted. The dusting process should be applied to every article of furniture in turn, and every crevice should be free from dust. The furniture should be carefully polished, also the dressing-table, mirror, and silver.

The bed-rooms should be periodically turned out, a regular routine being observed in carrying out the work. After the bed and most of the furniture have been covered up with dusting sheets, the bed-room carpet is thoroughly swept. It is well to remove from the room all small and portable articles of furniture—vases, dressing-table ornaments, etc., and to loop up the window-curtains. It is a good plan to scatter some tea-leaves or some salt over the carpet before sweeping, to freshen it up.

All polished furniture must be well polished by friction with a leather or silk cloth and by the occasional use of a prepared polish.

Occasional Duties. In a small establishment the housemaid will be responsible for the plate and glass used at table. Once a week she will have thoroughly to polish all the silver, using a good powder for the purpose. In such households the housemaid will lay every meal, wait at table, bring in the afternoon tea, answer the front-door bell, and show in visitors. When, in the spring, the house is subjected to a thorough cleaning, she will be responsible for much of the work to be done.

The lamps and globes used in lighting the house will be under the housemaid's care. If the cleaning of them also falls to her lot, she must be very careful over it. Special brushes, scissors, and cloths should be kept for oil lamps, and the trimming should be performed every day, for lamps never burn well without very careful attention.

Care of the Sitting-rooms. The housemaid will be responsible for the care of the dining-room and the drawing-room. Each room must be carefully freed from dust and dirt daily. A dustpan and brush should be used for the carpet, and every article of furniture must be well dusted and polished. In small households, where there are many grown-up daughters and few servants, the care of the drawing-room ornaments is often undertaken by a member of the family. This frees the housemaid and enables her to get on with other more important duties. Before the midday meal the housemaid should retire to her room and dress herself neatly for duty during the rest of the day. In the morning she will wear a light-coloured print dress and a large apron; in the afternoon these are discarded for a black dress and rather more ornamental muslin aprons. The housemaid's cap should be simple, and her collars and cuffs quite irreproachable in their whiteness.

Evening Work in the Bed-rooms. The housemaid is responsible for opening the bed-room windows at suitable times, and closing them again at sunset, or a little later. When it becomes dark, she must visit each bed-room, draw down the blinds and close the curtains. The bedspreads and pillow shams should be removed, and the bedclothes turned down and the night garments neatly arranged ready for use. Then the bed-room fires should be lighted, if the weather is cold, in time to make the room comfortably warm by bed-time. A can of hot water should be put in readiness in every room. These preparations can be made about an hour and a half before the time of dressing for dinner in a large establishment. Then, when the family are assembled at the meal, the housemaid will return to the bed-rooms, re-arrange the washstand, and set the room in order for the night. Candles should be placed in readiness, the candlesticks having been cleaned during the morning.

An energetic housemaid will get through her work in good time, and have leisure to sew for her mistress if required to do so. She should, therefore, be clever with her needle. Much household mending, remaking, and patching may fall to her share, and if she can do such work efficiently she will add greatly to her mistress's comfort.

THE PARLOURMAID

A parlourmaid's duties are practically those which would be performed by a single man-servant. She is usually kept in those households where no lady's-maid is found, in order that she may perform little services for her mistress. An extra maidservant, such as a parlourmaid, can add greatly to the comfort of the household without much extra trouble. In houses where a cook, a housemaid, and a young maid who assists both cook and housemaid are found, the parlourmaid is often the fourth servant engaged.

The Parlourmaid's Dress. The parlourmaid has only light duties to perform, and she will therefore be expected to be always neat and trim. She should wear a light print morning dress, with a muslin apron, and a black dress covered by a more elaborate apron in the afternoon. Her cap, cuffs, and collars should be invariably neat and clean. It is the duty of the parlourmaid to wait at table and arrange the meal beforehand. If she is assisted by the housemaid at table, she takes precedence of her. If she assists a manservant, she assists him as if he were a butler and she a footman.

Daily Routine. The daily routine of the parlourmaid closely resembles that of a single manservant, except that she will probably be called upon to assist in more purely domestic duties from which he would be exempt. She will wait more particularly on her mistress, and she may be called on to assist the housemaid in bed-room work, such as bedmaking, etc.

The parlourmaid will be responsible for the plate and glass used at table if no manservant is kept; and these she will have to wash and polish after use. Her time will be well filled in performing these duties, in laying the table for the various meals, in waiting at table, and in clearing away when the meal is over.

The parlourmaid is generally required to answer the dining-room and drawing-room bells, to open the front door, and to announce visitors. She will also bring in afternoon tea and serve the coffee after dinner. She will be responsible for the various sitting-room fires, and for the ventilation of breakfast and dining-room after meals.

THE HOUSE-PARLOURMAID

In small establishments, where but few servants are retained, one maid is engaged to perform the joint services of parlourmaid and housemaid. Such a maidservant lays the table for meals, waits at table, clears away afterwards, and washes the plate and glass. She also has charge of the bed-rooms, calling the different members of the family, and carrying up hot water. After breakfast, she makes the beds, generally with assistance, and dusts and arranges each room in turn. In the afternoon she answers the front-door bell, and brings in tea, etc. In the evening she sets the table for the last meal, waits during its progress, clears away afterwards, and then prepares the different bedrooms for the night. Thus the house-parlourmaid performs the most important duties of both housemaid and parlourmaid.

THE BETWEEN-GIRL

The between-girl is generally a young maidservant who spends part of her time in the kitchen assisting the cook, and part in the bed-rooms, etc., helping the housemaid. As the cook's assistant, she does much of her work that ordinarily would be undertaken by the kitchenmaid. She helps in the washing up of pots, pans, and dishes. The polishing of tins and copper utensils will fall to her lot, and she will probably prepare vegetables for cooking. She will peel or scrape the potatoes, and cut up and put the cabbages to soak in salt water, etc. The between-girl may also be called upon to clean boots and knives. Her work in assisting the housemaid will be to help to make the beds, and perhaps to arrange the washstands, dust the skirtings of the rooms, etc.

THE STILL-ROOM MAID

The still-room maid is now but seldom found in households. Her duties are simple, but as still-room maid a bright and capable young girl will find she has abundant opportunities of learning many useful details of household management. Generally, she is regarded as the housekeeper's assistant. When the housekeeper is busy making preserves of various kinds, the still-room maid will be kept busy picking the fruit, etc., used. She will occupy herself stoning fruit in less busy times.

The still-room maid is responsible for the arrangement of the housekeeper's room; she will light the fire there, sweep and dust the room, and lay the various meals. When the meals are prepared, she carries them in to the housekeeper's room, and waits at table on the upper servants, who take their meals there. In some households she arranges the flowers for the various rooms, and prepares the dishes of sweetmeats and dessert for the dining-room.

THE LAUNDRYMAID

The services of a laundry-maid are seldom requisitioned, except in large houses in the country. The difficulty of conducting laundry work satisfactorily in a large town is sufficient reason for the work to be sent to the professional laundress, who will doubtless arrange to carry on her work on the outskirts of the town.

The laundrymaid generally performs her duties in a separate part of the house, either quite detached from the main building or else only communicating with it by a yard or passage. The building will comprise a wash-house, a room for ironing purposes, with properly constructed stoves, and probably presses or cupboards in which the various articles may be thoroughly dried.

Importance of her Work. The laundrymaid has a very important task, and much of the comfort of every member of the family depends on the excellence of her work. She must carefully avoid the use of all chemicals and bleaches, which so quickly rob and spoil fine underwear. She must also be a skilful ironer. The details of her work will be given under the section LAUNDRY WORK.

When the soiled clothes and house linen are given to her, she should carefully count and sort it. Stains and marks should be removed and the different classes of material sorted, in order that they may be subjected to the correct treatment. Some of the clothes will need careful soaking, and this may be done the day before the actual washing process begins.

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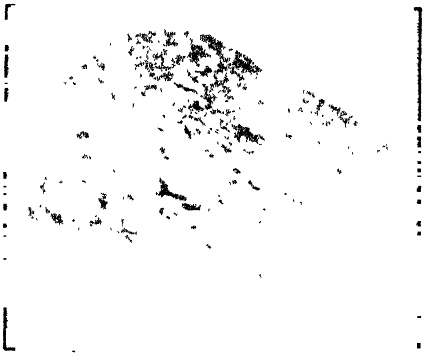
THE OLDEST, OR IGNEOUS ROCKS

How they Cooled and Crystallised into their present formation. The Ten Families of Igneous Rocks and their Characteristics

By W. E. GARRETT FISHER

WE have seen that the *igneous* rocks must be the oldest of all, and as it is always well to follow the order of Nature, we shall begin by giving an account of the most important constituents of the earth's crust which belong to this class. Then we shall describe the *sedimentary* rocks, which have been derived from the igneous by the work of natural agents, by weathering, attrition, and deposition. Lastly, we shall glance at the *metamorphic* rocks, which share the characteristics of both these main classes.

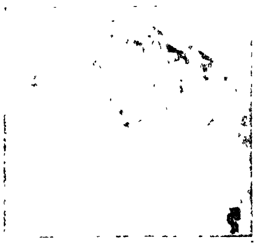
The Igneous Rocks. The *igneous* rocks, as their name implies—from the Latin *ignis*, fire—have come into existence through the action of heat. The older geologists divided them into two great groups, according to the circumstances in which they were prepared in the vast laboratory of Nature. Looking back at the history of the earth, as described in an earlier chapter, we see that the whole substance of which the earth's crust is now composed was once in a state of fusion. Thus every rock which we can find on the surface of the earth must once have formed part of an igneous mass; in other words, it was once liquid, like the lava which pours from the vent of an active volcano or the slag of a blast-furnace which is skimmed off the molten iron. But it would be vain to hope to find any part of the earth's surface still in the condition in which it was left when the molten rocks first solidified. The natural agents of change, which we shall study in a later chapter—wind and rain, ice and running water, and all the powers of the air—have been at work for countless ages to modify those primitive conditions.



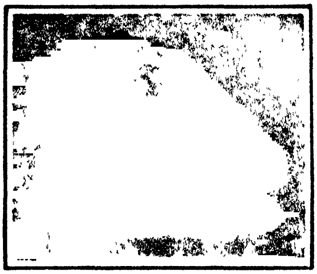
23. PUMICE

Volcanic and Plutonic Rocks. It is clear, however, that the igneous rocks which we now recognise have had their origin in two ways. They may have been solidified deep down beneath the surface of the earth, and have gradually made their appearance at the level of the ground, where we can now study them, by the double action of those forces which gradually upraise the lower strata in one part of the earth, while they depress the upper portions of the crust in another; or they may have been exposed to view by the slow denudation which is caused by the action of the weathering agents, which also break these rocks down into sedimentary forms, and which are capable—given sufficient time—of removing strata thousands of feet in thickness, so that the giant masses of the Alps are but the trifling remains of the inconceivable mountains which once reared their summits into prehistoric sky. Again, the igneous rocks which we now find on the earth's surface may have been brought to the ground-level in a liquid form by what we call volcanic forces, as is even now happening at Vesuvius, Krakatoa, Mont Pelée, or the other active volcanoes which survive from the remote age when they were far more active and more numerous. Igneous rocks which were produced in the latter fashion are called *volcanic*, whilst those which solidified deep down, and have since been revealed, are called *plutonic*. These names are derived from those of two Greek deities—Vulcan, who was supposed to work inside the burning mountain of Etna at forging the bolts of Jove, and Pluto, who was the ruler of the under-world.

Physical Distinctions. These two divisions correspond to well-marked physical distinctions in the two classes of rocks. The volcanic rocks, which mainly cooled on or near the surface, naturally solidified far more quickly, and are therefore marked by a much finer crystalline structure [see PHYSICS]. Sometimes—as in obsidian, or the so-called volcanic glass—they show no crystalline structure at all. Often they are full of holes, or vesicles, left by the escape of the gases with which they were charged when they first escaped from the vent of the volcano. Pumice-stone [23], in which the holes are more extensive than the substance, is a familiar instance. In general, they closely resemble the slag which the student can examine on the refuse heaps of a blast-furnace. Volcanic products may be *superficial*, poured out in vast sheets on the surface, or *intrusive*, thrust up in *dykes* or *bosses* from the hot interior. The plutonic rocks, however, solidified deep down under the earth, and consequently cooled so slowly that they had time to develop a well-marked and frequently coarse crystalline structure. The immense pressure of the superincumbent rock-masses—often 10 or 12 miles thick—compacted these rocks as they cooled, and gave them a close texture which left no room for the vesicles, or bubbles, so characteristic of the volcanic rocks. There are other distinctions, but these two are sufficient for the beginner to note. Volcanic rocks show small crystals, or none at all, and are often loose in texture or full of holes. Plutonic rocks are close in texture, and show large crystals. For the purposes of elementary descriptive geology, however, this distinction, though it must be clearly understood, need not be used in classifying the igneous rocks. The same rock is found in both conditions, according to the circumstances in which it was produced.

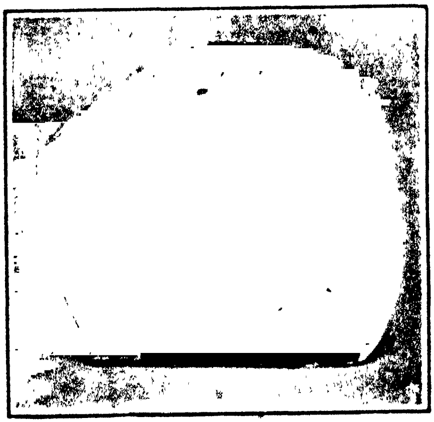

24. GRANITE, WITH CRYSTAL OF FELSPAR

Crystallisation of Rocks. Once upon a time all the igneous rocks existed in the form of a liquid lava. This liquid was closely akin to ordinary molten window-glass, which consists, like it, of a mixture of silicates. Of course, it must not be thought of as transparent, because it contained a great many impurities and colouring matters from which the glass of our manufacture is carefully purified or kept free; but in all essentials it was glass, and sometimes cooled, as in the case of obsidian, into a substance hardly to be distinguished from the coarse glass which is made for bottles. If it was allowed to cool slowly, however, its components arranged themselves into crystals of the fundamental forms corresponding to their chemical composition, and the slower the cooling the more complete was this process of crystallisation. Sometimes it was cut short in the middle. Part of the liquid had crystallised when the remaining *magma*—as it is technically called—was solidified so fast that it had not time to form crystals. Consequently, we find igneous rocks which may be wholly crystalline, like some granites, or partly crystalline, with the crystals set in a formless *matrix*, like porphyry, or not crystalline at all, like obsidian.


25. GRANITE

Again, the igneous rocks differ widely in their chemical composition, though they are all composed—with insignificant exceptions—of the minerals which have already been described. It is true, by the way, that the exceptions are insignificant from a geological point of view; but, humanly speaking, we must treat them with respect, as they include some of the ores from which our currency and much of our manufactures are derived.

Classification of Igneous Rocks. There is as yet no thoroughly satisfactory *classification* of the igneous rocks. There are several more or less efficient systems by which such a classification may be attempted. It is quite unnecessary to trouble the learner with an account of these. One need only say that rocks may be sorted into groups in different ways, according as we consider their chemical composition, their texture, the minerals of which they are built up, their mode of occurrence in the field, their origin, or their distribution in time (geological age) or space (locality). Various attempts have been made to discover a really scientific principle of classification, but as yet they have not been wholly successful. It depends on the object of study whether one or another of the various methods proves to be the most convenient. For our purpose, the learner may be recommended to the classification adopted by Sir Archibald Geikie in his "Text Book of Geology," Book II., Part 2, Sect. vii., where it may be studied at length by those who desire a closer acquaintance with the leading igneous rocks than we can give in these necessarily brief pages. It will be understood that the student must supplement this part of the course by an examination of the various rocks, both in a museum and in the field, and, if possible, by some work in a petrological laboratory, and in a field class. It is sufficient here to give an abstract of Sir A. Geikie's classification, which is based on the chemical and mineralogical composition of the igneous rocks, and arranges them in a progressive order, according to the proportion of silica which they contain, from the most acid to the most basic.

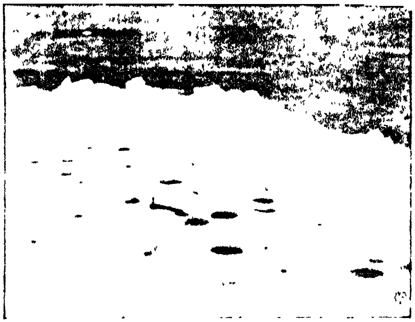

26. MICA (MUSCOVITE)
From Madras

[See the course on CHEMISTRY for explanation of these terms.] There are ten families of the igneous rocks, which Sir Archibald Geikie divides as follows.

Granite Family. This is by far the most important family of igneous rocks. The granites and their allies compose a very large proportion of the earth's crust, and everybody is familiar with the vast rock-masses and imposing cliffs of granite which play so large a part in the harmonies of the terrestrial landscape and in the operations of human architecture. They are chiefly plutonic in origin.

GRANITE consists typically of the three minerals, quartz, felspar, and mica, which form a thoroughly crystalline aggregate. There are very numerous kinds of granite, which vary (*a*) in the size of the crystals, sometimes so coarse as to be several inches in diameter, sometimes so fine that the naked eye cannot distinguish the crystals of the various minerals from one another; (*b*) in the chemical composition of the felspar and mica [see section on MINERALS]; (*c*) in the presence of other minerals in addition to the quartz and felspar which are essential to the constitution of a granite. For a more detailed account of these varieties the student must refer to Geikie—or to Teall's "British Petrography." He will be well advised also to study all the specimens of granite in any accessible geological museum, from which he will learn how a single rock may present itself in innumerable and exceedingly varied forms, which, nevertheless, can all be referred to a single family. They are the most acid—contain the most silica—of igneous rocks. [**24-26**]

GRANITE-PORPHYRY is a fine-grained granitoid rock, which consists of a very fine crystalline matrix of quartz and felspar, looking almost homogeneous to the eye, through which are scattered large crystals of felspar.



27. GIANT'S CAUSEWAY
Showing basaltic columns

QUARTZ-PORPHYRY is a rock consisting of a close-grained matrix (grey, brown, or pink) of quartz and felspar, through which are disposed distinct crystals of quartz. These porphyries—a term reserved for rocks consisting of finely crystalline and apparently homogeneous ground-masses, through which larger crystals are scattered—supply some of the most ornamental of our building stones. They are often confused in popular language with the marbles.

Rhyolite Family. The *rhyolites* are mainly of volcanic origin. Their name signifies this, being derived from the Greek word "to flow." They are distinguished from one another by variations in texture, depending on the conditions in which they cooled from the great lava outbursts of the early world.

RHYOLITE is a typically acid lava, with a high percentage of silica (77 or more). It varies much in structure and texture. Some variations consist of a crystalline aggregate of quartz and felspar which might be mistaken for granite; but the more common form is that of a finely crystalline ground-mass of quartz and felspar, in which occasional larger crystals of these minerals are scattered.

OBSIDIAN, or volcanic glass, is a glassy form of rhyolite which strongly resembles bottle-glass, and, like it, breaks with a conchoidal fracture. It is usually black, brown, or green. About 75 per cent. of its composition is silica, with about 13 per cent. of alumina and traces of other oxides. Its glassy structure is due to its having solidified so rapidly that there was no time for crystals to form.

PUMICE is a rhyolite which has cooled whilst so full of escaping gases that it has developed a spongy, cellular texture, like petrified froth. It is a characteristic volcanic product.

FELSITE is a rhyolite which was originally glassy, but has been devitrified by the process of time until it has developed a characteristic structure, which often causes it to be confused with conglomerate.

PITCHSTONE represents a still further stage of devitrification, and has a resinous or pitch-like lustre, whence its name. It is a volcanic glass, containing tiny crystals of quartz, felspar, hornblende, etc.

Syenite Family. *Syenite*, the rock of Syene, is a holocrystalline mixture of felspar and hornblende, with which mica, augite, magnetite, and quartz are sometimes associated. A typical syenite is a coarse-grained mixture of flesh-coloured orthoclase felspar and black hornblende. There are many varieties of syenite, which are chiefly found as volcanic or intrusive sheets and dykes. Though less abundant than the granites, they play an important part in the formation of rock-masses.

Elaeolite-Syenite Family. These are also intrusive rocks of volcanic origin, which are characterised by the association of the variety of nepheline known as elaeolite with orthoclase felspar. No quartz is to be found in them, since they do not contain enough silica to crystallise out in this form.

Diorite Family. These rocks possess a granitic structure, but contain less silica and seldom any free quartz, whilst they differ from the syenites in containing felspar as plagioclase instead of orthoclase—soda-lime felspar instead of potash felspar. From their typical colour they were formerly known as "greenstones"—a term which has no scientific foundation, though it is still often used for convenience in a hasty classification of rocks in the field.

DIORITE is a holocrystalline mixture of plagioclase and hornblende, with traces of other minerals, such as mica and magnetite. It contains about 60 per cent. of silica.

Trachyte Family. The *trachytes* are volcanic rocks whose name signifies that they present a roughness to the finger. Their essential constituent is sanidine, a glassy variety of orthoclase felspar. *Trachyte* is a lava of tertiary and post-tertiary times, which is found in most of the old volcanic regions of Europe. Special varieties are *phonolite*, or *clinkstone*, which gives out a characteristic ringing sound when it is struck with a hammer, and *trachyte glass*, a variety of volcanic glass which is less acid than obsidian.

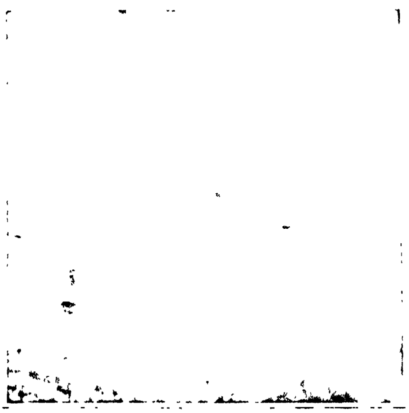
Andesite Family. *Andesites*—originally found in the Andes—are more basic than the trachytes, from which they are also distinguished by having plagioclase as their felspar. They usually have a compact ground-mass, in which prisms of felspar are scattered. They contain about 60 per cent. of silica.

Gabbro, Dolerite, and Basalt Family. This is an interesting series of igneous rocks, characterised by their small percentage of silica. "At the one extreme come rocks with a holocrystalline structure like the gabbros, passing into others of a hemicrystalline character (dolerites) where, amid abundant crystals, crystallites, and microlites, there are still traces of the original glass, and then graduating into types where the texture is still closer, with more abundant ground-mass and often a more basic composition (basalts), until at the other end come true basic volcanic glasses, which externally might be mistaken for the pitchstones and obsidians of the acid rocks. The more coarsely crystalline (holocrystalline) varieties are almost always intrusive in bosses, sills, or dykes. Those of closer texture are often found as superficial lavas as well as in intrusive forms" (Geikie). After the granites, this is probably the most important and numerous group of igneous rocks. We can only find space for a few notes on the leading types.

GABBRO is a coarsely crystalline rock composed of plagioclase (soda-lime felspar), with pyroxene, olivine, and magnetite. The silica is about 50 per cent. The structure is usually similar to that of granite or granitoid.

DOLERITE is usually holocrystalline, and consists of plagioclase, with a ferro-magnesian mineral (augite or olivine) and magnetite. Silica about 50 per cent.

BASALT is a black, very compact, apparently homogeneous rock, with a conchoidal or glassy fracture, in which the constituent minerals can only be observed with the microscope, which reveals a minute crystalline structure. Basalts consist of plagioclase, pyroxene, olivine, and magnetite, and contain from 33 to 50 per cent. of silica. The basalts, of which there are numerous varieties, are typical products of volcanic activity. Some occur as the remains of superficial outbursts, but more commonly they are intrusive, and appear in great dykes and bosses which have been thrust up to the surface of the earth from the heated regions of the inferior crust. Basalt often passes into the condition of volcanic glass when it has cooled very quickly. [27, 28]



28. BASALTIC COLUMNS
Showing sides of prisms and jointing

Limburgite Family. These are volcanic rocks of highly basic composition, in which felspar is wholly absent. *Limburgite* is a fine-grained to vitreous rock, composed of augite, olivine, magnetite, and apatite. Silica about 42 per cent. *Augite* consists of augite and magnetite in a glassy matrix.

Peridotite Family. These rocks are the most basic and contain the least silica, averaging about 40 per cent., of all igneous rocks. Their chief constituent is olivine, with augite, hornblende or mica, and magnetite. They are holocrystalline when fresh, but are usually found in altered states. They are mainly intrusive forms of volcanic rocks.

SERPENTINE, as a rock, is a massive form of the mineral serpentine, which is a product of the alteration of peridotites containing olivine. It is a compact or finely granular rock of a characteristic dirty green colour, streaked with brown or red, like the scales of a serpent, whence its name. It is a hydrous magnesian silicate, which is formed by the action of superficial agents from the olivine originally intruded by volcanic action.

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OBJECT DRAWING, & PRACTICAL GEOMETRY

Continued from page [illegible]

A Lesson on the Ring or Wheel. Circles Touching Lines and Circles. Foiled Figures of Semicircular and Tangential Arcs

By WILLIAM R. COPE

The Ring. Our model for this lesson is the ring, which well illustrates two important principles to be observed—*viz.*:

1. That although the rim of an object, such as that of a cup, vase, wheel, etc., may be the same thickness all round, yet it will not necessarily appear so.

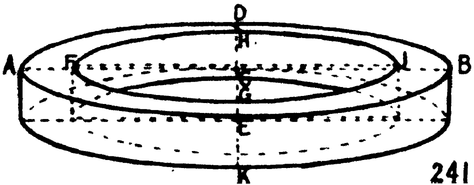
2. How the wheels of vehicles, machinery, etc., should be drawn, as regards not merely the apparently varying thickness, but the apparent *direction* of their major axes.

Horizontal Positions of the Ring. Figures 241 and 242 indicate how the construction should be made when the ring is lying in a horizontal plane. The first difficulty is with regard to the *direction* of the major axis, and when determining this the student should not be misled by the apparent direction of the edges of surrounding objects, such as the edges of, say, a board, box, table, etc. *Whatever the apparent direction of the latter may be, the major axis of the ring or wheel will always appear horizontal when the ring is lying in a horizontal plane.* This should be verified by the student by placing the ring on a flat table or board, so that the edges of the latter are receding from him in various directions, as in 247 and 248. Therefore, commence the construction by drawing a horizontal line AB for the major axis of the top outer ellipse, carefully observing how high or how low it should be with regard to neighbouring objects.

When the length of AB has been fixed, bisect the axis in the point C, and through C draw the minor axis DE at right angles to AB. Then find out the apparent length of this minor axis compared with AB, and through the four points A, B, D, and E draw the curve of the ellipse, which represents the outer top edge of the ring. Now we come to the most important principle to be observed concerning this and similar objects, and that is, *although the top inner edge is really parallel with the outer edge, it does not appear so.* By careful observation of the model it will be seen that the ring *appears considerably wider at AF and JB towards the ends of the major axis* than it does at EG and DH, the ends of the minor axis. The student should now make further experiments with cups, vases, jars, etc., and he will find that there is generally an apparently wider thickness at the ends of the major axis than at the ends of the minor axis. More illustrations bearing on this point will be given later when dealing with vases of various shapes. Thus it will be seen how important it is to determine the apparent thickness at AF, JB, EG, and HD very accurately. It should be noted that the major axis of the inner ellipse does not quite coincide with that of the outer ellipse, but is very slightly above. The further top thickness, DH, is also apparently slightly less than the nearer top thickness EG. Then draw the inner ellipse through the four points E, G, J, and H. Now find out the apparent upright thickness EK, which is *practically about the same* as AF or JB but *theoretically a little larger*, because EK is slightly nearer than AF or JB, but the difference is scarcely appreciable, unless the ring is very large. The lower outside edge, it must be remembered, is part of another ellipse vertically under the top outer one, which was drawn first. In 241 and 242 the construction shows the invisible portion by dotted lines. There is yet another curve, the lower and inner edge, which is but little seen in 241, but better in 242. This curve is also part of an ellipse, as shown in 241 and 242, which will explain better than words what the curve appears like, and its relation with the upper and inner ellipse.

Oblique Positions of the Ring. Figures 243 and 245 are representations of the ring in a leaning or slanting position. When beginners attempt to draw such views they generally make a very bad mistake about the *direction* of the major axis AB, because they do not use their eyes properly, and do not know the very good guide, that if the pencil is held so that it apparently passes through the two points C and D—the apparent intersections of the upper and lower inner edges—the major axis appears to be in *the same direction*, but not exactly in the same *position*, for the major axis is practically midway between the point E on the further side, and F on the nearer part of the outer edge. *The above guide holds good when the ring is in any position whatever* [see 241 to 245]. After the direction, position, and length of the major axis are determined, the construction is the same in method as in 241 and 242. The student should remember and *see* that the major and minor axes are always at right angles to each other.

Vertical Position of the Ring. Figure 244 is an interesting and important view, supposing the ring to be below the eye-level, and standing in a *vertical* plane, as the wheels of a cart or carriage might be. Here, again, beginners make errors, because they think the major axis must be upright since the ring is upright, *but it is not necessarily so*; in fact, the axis can only appear *vertical* when the centre of the ring is exactly on a level with the eye. The above statement should be compared with what was explained about the cylinder in the position shown in 148, and the student will find that the law is really the same, for the ring may be considered as a hollow cylinder with its



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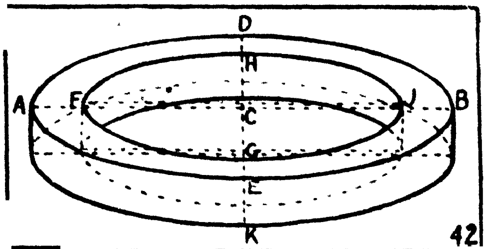

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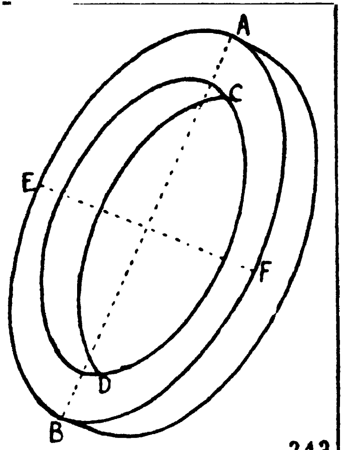

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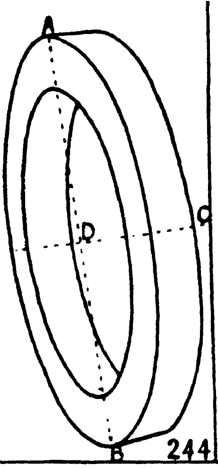

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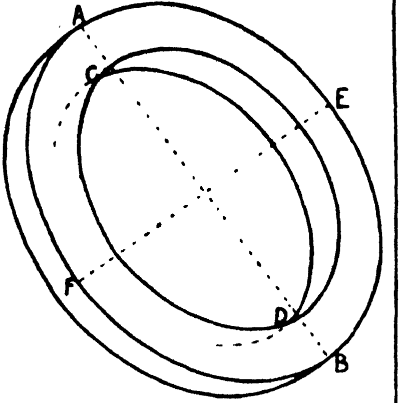

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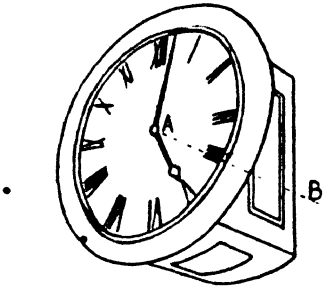

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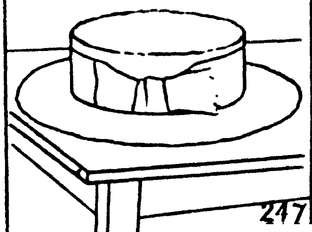

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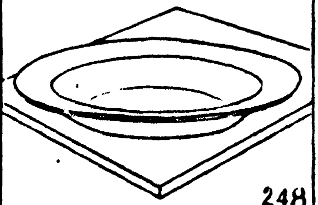

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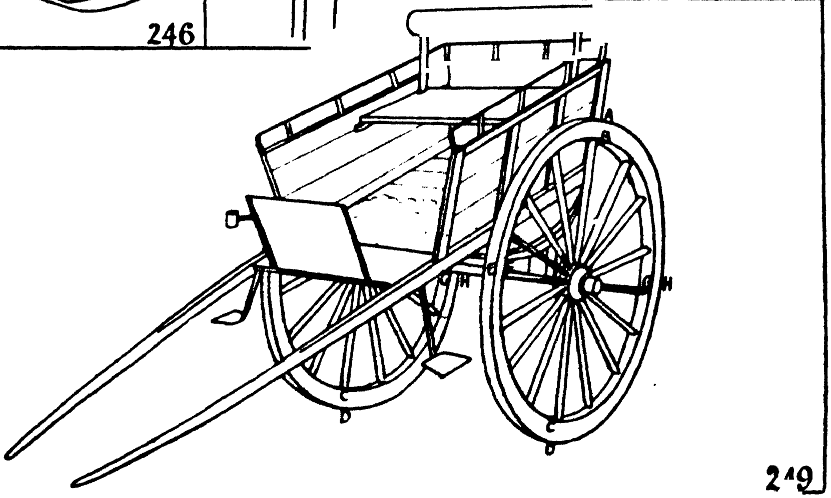

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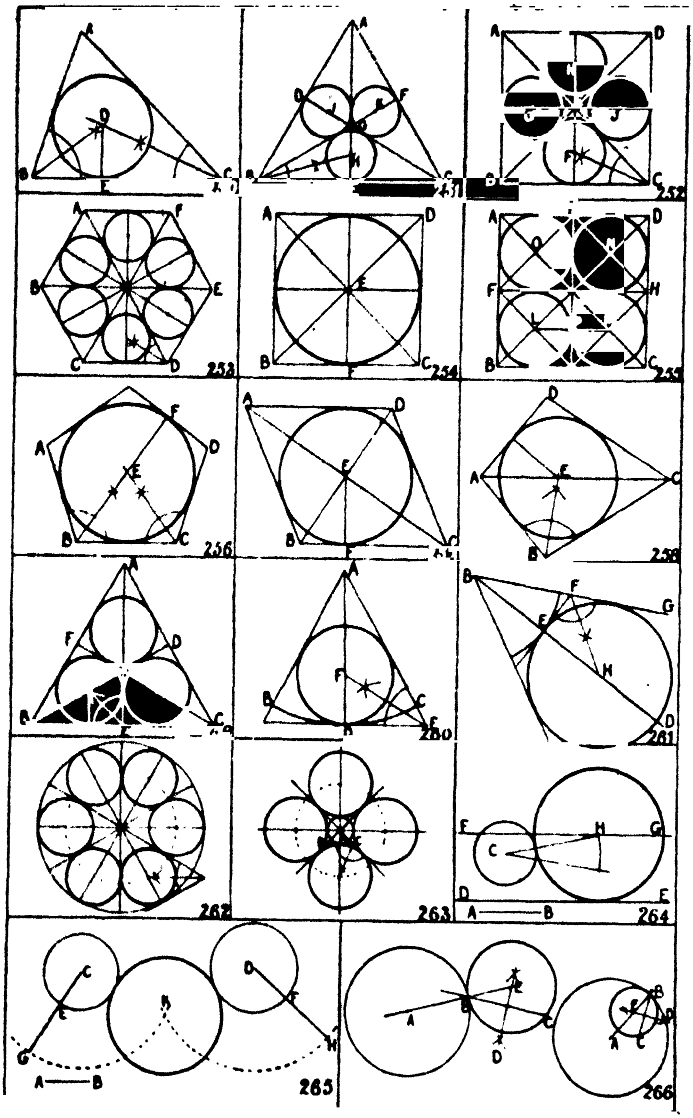
A LESSON ON THE RING AND OBJECTS SIMILAR IN CONSTRUCTION



CIRCLES TOUCHING LINES AND CIRCLES

axis receding to the right in 244 in the direction *DC*; therefore, the major axis *AB* must be drawn at right angles to *DC*—the axis of the object.

Application of Above Principles. See how the foregoing principle is applied in the drawing of the clock in 246, where an imaginary line through I. and VII. for the major axis of the dial is at right angles to *AB*, the axis of the clock, although the face is really in a vertical plane. The clock is assumed to be above the eye-level.

Again, in 249 the major axes of the two wheels are both at right angles to the axle of the cart. Thus, the longest direction of the wheels is apparently slanting, and yet the wheels are upright in reality. Further attention should be given to the width of the rim of the front of the clock in 246; the hat brim in 247; the rim of the plate in 248; and the widths *AB* and *CD* (at the ends of the major axes) of the rim of the wheels in 249, which are wider than *EF* and *GH* at the ends of the minor axes.

Rules and the Perceptive Faculties. It is necessary that students should not merely draw by rule, but they should endeavour to so train their perceptive faculties that, after a time, they may be able to see intuitively, nay, almost without effort, the varying changes in the appearance of an object. Rules, if correctly remembered, will give much guidance with regard to *how to see*. There are, unfortunately, many students who retain only a vague notion, or even, perhaps, a distortion or transformation, of some rule which has been explained to them, and then, of course, the rules are worse than useless. Therefore, try to remember rules correctly, and, as well, do all you can, by practising drawing, to improve the hand in skill and the eye in seeing aright.

PRACTICAL GEOMETRY

Circles Touching Lines and Circles.

The problems in this part depend for their solution upon the following truths in Euclid:

i. If a straight line be a tangent to a circle, and from the point of contact a line be drawn perpendicular to the tangent, the centre of the circle shall be in that line (Euc. III. 19).

ii. If one circle touch another internally in any point, the straight line which joins their centres being produced shall pass through the point of contact (Euc. III. 11).

iii. If two circles touch each other externally in any point, the straight line which joins their centres shall pass through that point of contact (Euc. III. 12).

250. To Inscribe a Circle in a Given Triangle *ABC*. Bisect any two angles *ABC* and *BCA* by lines intersecting at *D*. From *D* draw *DE* perpendicular to either of the sides of the triangle, then *DE* is the radius and *D* the centre of the required circle.

251. IN A GIVEN EQUILATERAL TRIANGLE *ABC*, TO INSCRIBE THREE EQUAL CIRCLES, EACH TO TOUCH ONE SIDE AND TWO CIRCLES. Bisect the angles by lines which also bisect the sides in *D*, *E*, and *F*, and intersect at *G*. Inscribe a circle in the triangle *GBC* (Prob. 217). Mark off *GJ* and *GK*, each equal to *GH*, then *J* and *K* are the centres of the other circles.

252. IN A GIVEN SQUARE *ABCD*, TO INSCRIBE FOUR EQUAL CIRCLES, EACH TO TOUCH ONE SIDE AND TWO CIRCLES. Draw the diagonals and the diameters intersecting at *E*. Inscribe a circle in the triangle *EBC* (Prob. 217). With centre *E* and radius *EF* mark off *EG*, *EH*, *EJ*, each equal to *EF*, then *G*, *H*, and *J* are the centres of the other circles.

253. IN ANY GIVEN REGULAR POLYGON (SAY *ABCDEF*), TO INSCRIBE AS MANY EQUAL CIRCLES AS THE FIGURE HAS SIDES, EACH CIRCLE TOUCHING ONE SIDE AND TWO CIRCLES. Divide the figure into equal triangles and inscribe a circle in each, as shown.

254. TO INSCRIBE A CIRCLE IN A GIVEN SQUARE *ABCD*. Draw the diagonals and diameters to find the centre *E*, and with radius *EF* describe the circle.

255. WITHIN A GIVEN SQUARE *ABCD*, TO INSCRIBE FOUR EQUAL CIRCLES, EACH TOUCHING TWO SIDES AND TWO CIRCLES. Draw diagonals and diameters as before. Join *F*, *G*, *H*, and *K*. The intersections *L*, *M*, *N*, *O*, with the diagonals, are the centres of the circles. Join *L* and *M*, then *LP* or *MP* is the radius required.

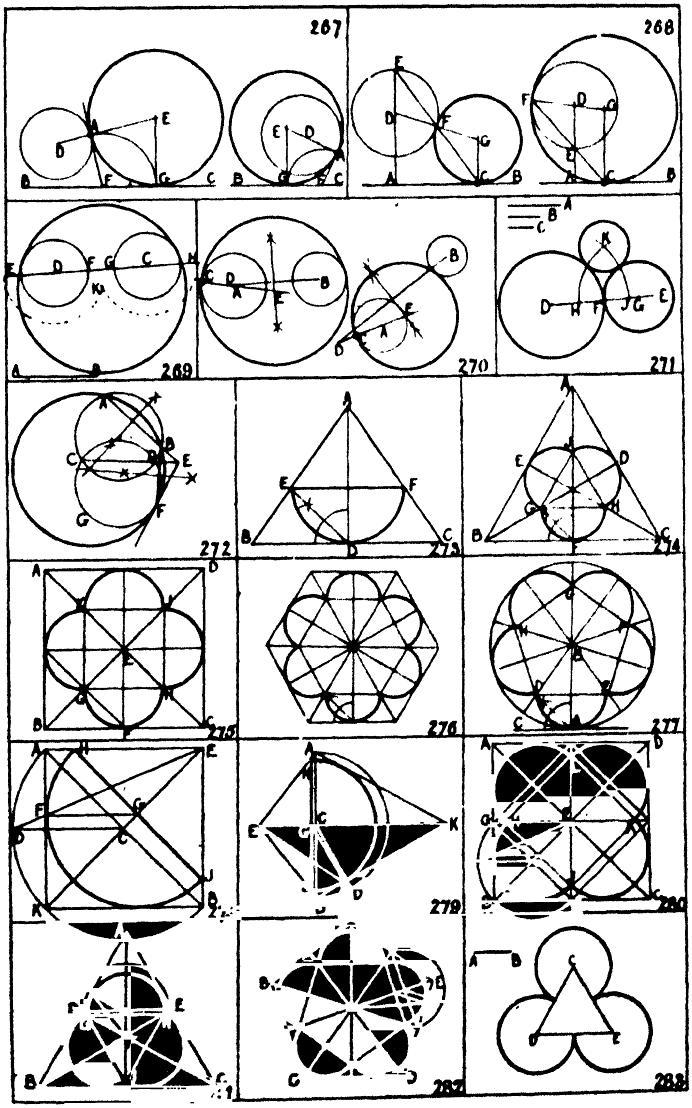
256. TO INSCRIBE A CIRCLE IN ANY REGULAR POLYGON. Bisect any two angles *ABC* and *BCD*, then *E* is the centre, and a perpendicular (say *EF*) from *E* to either of the sides is the radius.

257. TO INSCRIBE A CIRCLE IN A GIVEN RHOMBUS *ABCD*. Draw the diagonals to find the centre *E*, and a perpendicular (say *EF*), from *E* to either of the sides is the radius.

258. TO INSCRIBE A CIRCLE IN A GIVEN TRAPEZIUM *ABCD*. Draw the diagonal *AC*, and bisect one of the other angles, then *E* is the centre, and the radius is a perpendicular to either of the sides.

259. WITHIN A GIVEN EQUILATERAL TRIANGLE *ABC*, TO INSCRIBE THREE EQUAL CIRCLES, EACH TOUCHING TWO SIDES AND TWO CIRCLES. Bisect each of the angles by the lines *AE*, *BD*, and *CF*, thus obtaining three equal trapeziums, in each of which inscribe a circle as in 258.

260. TO INSCRIBE A CIRCLE IN A GIVEN SECTOR *ABC*. Bisect the angle by *AD*. Through



CIRCLES TOUCHING LINES AND CIRCLES. FOILED FIGURES

D draw a tangent DE to meet either AB or AC produced in E. Bisect the angle AED by the line EF intersecting AD at F, which is the centre, and FD the radius of the required circle.

261. To Describe a Circle to Touch the Arc of a Sector and the Two Radii Produced. Bisect the angle by BD intersecting the arc at E. Through E draw the tangent EF. Bisect the angle EFG by the line FH intersecting BD in H, which is the centre, and HE the radius of the circle.

262. To Inscribe Any Number of Circles in a Given Circle. Divide the circle into twice as many sectors as circles required, and inscribe a circle in each sector (Prob. 260). The centres are found as shown by the dotted circle.

263. To Describe Any Number (say Four) of Equal Circles About a Given Circle. Divide the circle as in 262 and produce the diameters. At the point A draw a tangent BC. Then proceed as in 261. The other centres are found as shown by the dotted circle.

264. To Describe a Circle of a Given Radius AB to Touch a Given Circle C and a Given Line DE. Draw FG parallel to DE at a distance equal to AB from it. With centre C and radius equal to the sum of the radius of circle C, plus AB, describe an arc cutting FG in H, which is the centre required.

265. To Describe a Circle of a Given Radius, Touching Two Given Circles Externally. Let AB be the given radius. Find the centres C and D of the given circles, draw radii CE and DF and produce them. Set off EG, FH equal to AB. With centre C and radius CG describe an arc. With centre D and radius DH, intersect in K. With centre K and radius AB describe the circle. If the arcs were continued the centre for another circle would be obtained.

266. To Describe a Circle to Touch a Given Circle A in a Given Point B, and to Pass Through a Given Point C, Either Within or Without the Circle. Join B and C. Bisect BC by a perpendicular DE. Join B and A and produce BA to meet DE in E, which is the centre and BE the radius of the circle required.

267. To Describe a Circle to Touch a Given Circle at a Given Point A, and a Straight Line BC. *First externally:* Find D, the centre of the given circle, and draw DE through A. At A draw the tangent AF meeting BC in F. With F as centre and FA as radius describe an arc cutting BC in G. At G erect a perpendicular to BC intersecting DE in E, which is the centre. *Second, including the given circle:* Draw the radius AD and produce it beyond D. Draw the tangent AF meeting BC in F. Make FG equal to FA. At G erect a perpendicular to BC meeting AE in E, which is the centre, and EG the radius.

268. To Describe a Circle to Touch a Given Circle and a Straight Line AB at a Point C. *First externally:* Find D, the centre of the given circle, and draw DA perpendicular to AB, and produce it to E. Join EC. Through F (where EC cuts the given circle) draw DG intersecting a perpendicular from C in G. G is the centre and GC the radius of required circle. *Second, including the circle:* Find the centre D, and draw the perpendiculars AD and CG as before. Through E (the intersection of AD with the circumference of the given circle) draw CF cutting the circle in F. Through F and D draw FG intersecting CG in G, which is the centre, and GC the radius of required circle.

269. To Describe a Circle of a Given Radius AB, to Touch Two Given Circles, and Include Them. Join the centres of the circles and produce the line both ways. Mark off FE and GH equal to given radius AB. With centres C and D and radii CH and DE respectively, describe arcs intersecting at K, which is the centre of circle required.

270. To Describe a Circle to Touch Two Given Circles A and B, and One of Them in a Given Point C. Join A, the centre, with C and produce. Make CD equal to the radius of the other circle B. Join B and D and bisect BD by a perpendicular intersecting CA produced in E, which is the centre, and EC the radius of the required circle.

271. To Describe Three Circles to Touch Each Other, their Radii A, B, and C being Given. Draw any line DE, and set off on it DF and FG equal to A and B respectively. With D as centre and DF as radius describe one circle. With G as centre and GF as radius describe a second circle. Mark off FH and FJ each equal to C. With centre D and radius DJ describe an arc. With centre G and radius GH describe another arc intersecting the former in K, the centre of the third circle, whose radius is C.

272. To Describe a Circle which shall Pass Through Two Given Points A and B, and Touch a Given Circle FGC. Describe any circle passing through A and B, and cutting the circle FGC in C and D. Through C and D draw CE to meet AB produced in E. From E draw a tangent EF to the circle FGC. Then F is the point where the described circle will touch the given circle. Describe a circle to pass through the points A, B, and F [see 200].

Foiled Figures. The following problems relating to foiled figures are exceedingly useful in geometrical design for window tracery and other ornamental forms. It should be observed that in 274–282 the foiled figures are formed of *semicircular* arcs, but in 283 of *tangential* arcs.

273. To Inscribe a Semicircle in an Isosceles Triangle ABC. Bisect the angle BAC by AD. Bisect the angle ADB by DE cutting AB in E. Through E draw EF parallel to BC. Upon EF describe a semicircle.

274. To Inscribe, in an Equilateral Triangle ABC, Three Equal Semicircles, Each Touching One Side and having their Diameters Adjacent. Bisect each angle of the triangle by the lines AF, BD, and CE. Bisect the angle AFB by the line FG cutting BD in G. Through G draw GH and GJ parallel to BC and BA respectively. Join HJ. On the lines HG, GJ, and JH describe semicircles as shown.

275. In a Square $ABCD$, to Inscribe Four Equal Semicircles having their Diameters

Adjacent, Each to Touch One Side of the Square. Draw the diagonals and diameters. Bisect the angle *EFB* by *FG*, and obtain the inner square *GHJK*. Upon each side of this square construct a semicircle.

276. Within a Regular Polygon, say a Hexagon, to Inscribe as Many Semicircles as the Figure has Sides, Each Touching One Side and having their Diameters Adjacent. Divide the polygon into equal triangles and inscribe a semicircle in each as shown.

277. To Inscribe any Number of Equal Semicircles in a Circle, Each to Touch the Circumference, and have their Diameters Adjacent. Divide the circle into twice as many equal parts as semicircles required. Draw the diameters, and at the end of one of them (say at *A*) draw a tangent. Bisect the angle *BAC* by *AD*, and obtain *BE*, *BF*, *BG*, and *BH*, each equal to *BD*. Draw the pentagon *DEFGH*, and describe a semicircle on each side.

278. To Inscribe a Semicircle in a Given Square *AKBE*. Draw the diagonals *AB* and *KE*. Describe a semicircle on *AB*. Draw *CD* perpendicular to *AK* and cutting the semicircle in *D*. Join *DE*, and through the intersection *F* draw *FG* parallel to *DC*. *G* is the centre and *GF* the radius of the required semicircle.

279. To Inscribe a Semicircle in a Given Trapezium *AEBK*. Draw the diagonals. On the shorter, *AB*, describe a semicircle. From *C* draw *CD* perpendicular to *BK* and cutting the semicircle in *D*. Join *DE*, and proceed as in last problem.

280. In a Given Square *ABCD*, to Inscribe Four Equal Semicircles, Each to Touch Two Sides, and have their Diameters Adjacent. Draw the diagonals and diameters as shown. In each small square, as *BEFG*, inscribe a semicircle as in **278**.

281. In a Given Equilateral Triangle *ABC*, to Inscribe Three Equal Semicircles having their Diameters Adjacent, and Each Touching Two Sides of the Triangle. Bisect each angle of the triangle by lines which divide the triangle into three equal trapeziums. In one trapezium (say *ADFE*) inscribe a semicircle as in **279**. Make *FJ* equal to *FH*. Join *HJ* and *GJ*. Upon *HJ* and *GJ* describe semicircles.

282. In any Regular Polygon (say a Pentagon *ABCDE*), to Inscribe a Number of Equal Semicircles, each to Touch Two Sides of the Polygon, and have their Diameters Adjacent. Draw the lines bisecting the angles and giving five equal trapeziums. In each trapezium inscribe a semicircle as in **279**.

283. To Describe a Trefoil of Tangential Arcs, the Radius *AB* being Given. Construct an equilateral triangle *CDE* with sides each double of *AB*. With each angle as centre and *AB* as radius describe the arcs.

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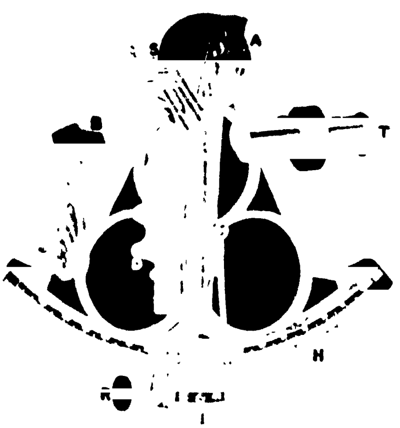
MARINE or HYDROGRAPHICAL SURVEYING

Explanation of the Sextant. Artificial Horizon and the Station Pointer. Observations of the Tides and the Use of Floats

By Professor HENRY ROBINSON

IT is not proposed in this article to refer to deep-sea soundings and other special works of an allied nature, but to confine the subject to that which comes within the province of a civil engineer.

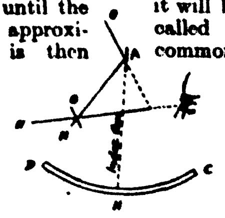
Some of the instruments that have already been described in LAND SURVEYING are also used in marine surveying. There are, however, several instruments which will be explained before proceeding with the "field" operations.



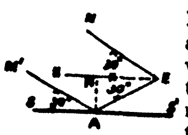
63. SEXTANT

The Sextant. This hand instrument [63] is very useful for measuring both vertical and horizontal angles up to 120°. Its construction is as follows: A mirror (A), called the *index glass*, is fixed to an index arm (I), which carries a vernier that reads on the graduated scale (H), and from it the values of the observed angles are obtained. Any movement of the index glass throws a reflection into another mirror (B), called the *horizon glass*. The latter is rigidly fixed, the lower half of the glass being silvered and the upper clear. Thus, a ray of light coming from the direction of N [64] passes through the clear portion of the glass B, down the telescope, to the eye. A ray from the direction of an object at O strikes the mirror A, is reflected to M, and then, through the telescope, to the eye. Therefore, through the telescope come rays both from the direction of N and O, each set forming a perfect image. By operating the index glass (A), images will appear to be moving over each other until the two under observation appear and approximately coincide. The index arm is then clamped by a screw, the screw used the objects until their coincidence is perfect.

65. ARTIFICIAL HORIZON



64. ARRANGEMENT OF MIRRORS IN SEXTANT



66. ANGLES OF REFLECTION

The angle between the two objects can now be read. A small magnifying glass (M) is provided to assist the observer in reading the vernier. Smoked or tinted glasses (S) of various shades are provided for use in strong light, or when taking observations to the sun.

To determine the altitude of the sun, direct the telescope on to the horizon through the clear portion of the glass B, the instrument being held in the right hand by the handle (D). Unclamp the index arm (I) and bring the reflection (made by the mirror A) of the sun on to the silvered portion of the glass B. Clamp and adjust the index arm, as previously explained, so that the top limb of the sun coincides with the line of the horizon, then read off the value of the angle in the usual manner.

The Sextant at Sea. When measuring the altitude of an object above the "sensible" horizon with the sextant at sea, a correction must be made to allow for the "dip" of the horizon—*i.e.*, its apparent angular depression below a truly horizontal line traversing the eye of the observer. The amount of this correction is uncertain owing to the variable refractive power of the atmosphere. Rankine gives a formula for finding the value of the correction:

$$\text{Dip in Seconds} = \tfrac{9}{10} \times 206264''\cdot 8 \sqrt{\frac{2h}{r}}$$

$$= 57''\cdot 4 \sqrt{h} \text{ in feet.}$$

When h = height of observer's eye above the sea

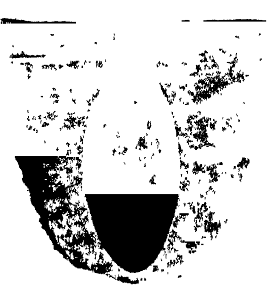
r = radius of curvature of the surface of sea.

Before leaving the description of the sextant it will be necessary to explain an instrument called the "artificial" horizon, which is commonly used with the sextant.

Artificial Horizon. The angles observed with the sextant at s measured the *sensible* horizon, which, however, is not always possible on land, therefore an "artificial horizon" is necessary. The most suitable form of artificial horizon is that consisting of a tray of mercury having a glass cover or roof. The illustration [65] shows one made by Mr. J. H. Steward. The angle observed with the artificial horizon is double the actual angle.

The theory of the instrument is described by Mr. W. F. Stanley in his book on "Surveying Instruments," and is briefly as follows.

A small luminous body [66, M'], placed at a distance will have its image reflected from a level reflecting surface [SS'], at an angle equal and opposite to the incident ray, the angles M'AS and EAS' being equal. Let E be the place of the eye or the sextant. This will receive an image from the distant body M', sensibly parallel with M'A in ME. The angle MEA will therefore be double the angle of incidence M'AS; the half angle produces the horizontal line EH (provided the plane of reflection SS' is level). Therefore, if we take half this angle MEA, as it appears in the sextant, it will give an angular position of the object in relation to the horizon at the height of the eye, or be tangential to the surface of the earth. If M'AS be 30°, the angle AEM will be 60°, showing the elevation of the object to be half this angle—that is, 30°. The sextant takes angles up to 120°, therefore 60° will be the limit of meridian altitude that the artificial horizon will measure.

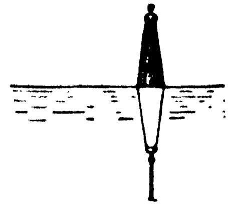

67. BOTTLE FLOAT

Tides. It is necessary for the purposes of some marine surveys to take careful observations as to the set of the tides. It will be impossible in this course to deal exhaustively with all the peculiarities of tides, but a few brief observations are necessary in order that some general information may be conveyed. Complete records of the tides in any particular locality would involve months of careful observation on account of the variations that take place at different times of the year. In one place the normal number of tides per day of six to seven hours for each rise or fall will often differ from another place which will have tides of longer or shorter duration. The reason of the varieties in the motion of tides is due to several causes, the height of the barometer being one. It is found that a high barometer accompanies a low tide and a high tide synchronises with a low barometer.

The relative positions of the sun and moon, the direction of the wind and the conformation of the land affects the tides; it is the two last that produce the greatest irregularities. The method employed for gauging the rise and fall of tides, when no pier, wharf, etc., are available, is by erecting a *tide-pole*. These poles are generally constructed out of an old spar, properly marked in feet, and firmly weighted and fixed in the sea-bed in the most sheltered place possible. To obtain the accurate time of high and low water, observations must be taken every few minutes, some little while before and after high and low water, the exact time being calculated from the results thus obtained.

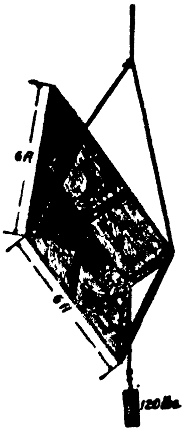
The direction of the tide must be obtained by float observations, as explained later.

It must not be assumed that because it appears to the eye that the tide is flowing in a certain direction that such is the case. Take for example a tidal river. The land water being of a different specific gravity, and warmer than that of the sea-water, will flow over the incoming tide, thus producing two distinct currents in opposite directions. This peculiarity is of extreme importance to engineers, and it is only by careful float observations that the true direction of currents can be obtained.



Floats. The direction of currents can be accurately obtained by using various forms of floats. The action of the wind on the exposed surface of a float which projects too much from the water may cause it to travel in a direction totally different to that of the current. Therefore a float must be made so that as little surface as possible is exposed to the wind. A simple and useful form of float may be constructed from a bottle, as shown by the illustration [67].

Where it is necessary to determine currents at considerable depths a float constructed as shown by 68, or something similar, must be employed.



68. DEEP-SEA FLOAT

The method of determining the position of a float from time to time is similar to that explained hereafter when dealing with the location of soundings [70].

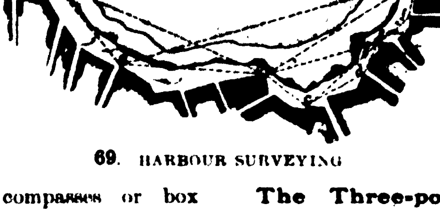
In carrying out a marine survey on a coast line, the configuration of which has been obtained by triangulation (such as shown in 69), the method to be employed must to some extent depend on local circumstances. The nature of the sea-bed must be examined either by diving operations or by borings, the results of which should be noted on the plan, or chart, by reference letters, such as "r" for rock, "s" for sand, "m" for mud, and so on.

All moorings, buoys, beacons, groynes, lighthouses, prominent rocks, etc., should be clearly and accurately shown. The bed of the sea is surveyed by *soundings* taken from a boat with a loaded line. All soundings on published charts are given (in fathoms) for low water at ordinary spring tides.

The position of each sounding can be obtained either by angular measurement from the shore to the boat or from the boat to the shore.

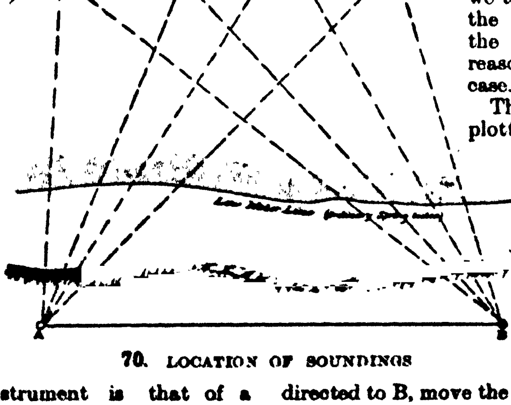
The following is a description of the first method :

Set out on the shore a base line [70, AB] of known length and position with regard to the chart or plan. At A and B set up theodolites. The observers follow with the telescopes of the instruments the movements of the boats from which the soundings are being taken. On receiving a prearranged signal from the boat, each attendant observes the angle between the boat and the base line, thus locating that particular sounding. The time also is noted. These angles can also be obtained, when minute accuracy is not required, by employing prismatic compasses or box sextants. From the angles thus obtained at the stations A and B, the position of each sounding (as shown by the points C, D, E, and F on the illustration) can be determined and plotted on the chart or plan by means of a protractor.



69. HARBOUR SURVEYING

A better and more convenient method of obtaining the positions of the soundings is by taking observations from the boat with the sextant, and then by means of the *station pointer* they can be plotted directly on the chart. The following description will explain the whole operation :



70. LOCATION OF SOUNDINGS

The Station Pointer. The illustration [71] shows the arrangement of this useful instrument, which is employed, as already stated, for plotting on a chart or plan the position of a boat from which angular observations have been taken with the sextant to three well-defined points on the shore, the positions of these points being known. The form of the instrument is that of a circular metal protractor with three arms radial to a common centre (S), one fixed (A), and two movable. The movable arms are provided with verniers and screws. The theory of the instrument is based upon the 21st proposition of Euclid, Book III., which shows that the angles subtended by the chord of the segment of a circle measured from any point in the circumference are equal.

Thus, if the angle [72] between A and B is observed to be, say 60°, the observer knows that he is somewhere on the circumference AEDB, on any part of which, as at E or D, the angle subtended by AB will be the same. The measurement, therefore, of an angle between two objects gives this information—that the observer is on the circumference of a circle which passes through two objects, the diameter of which varies according to the angle, with an equal length of AB. This will be seen by comparing 72 and 73. In the former, AEB = 60°, and in the latter, AGB = 30°. Therefore, for example, if a mariner finds that a rock exists at X, and two well-defined objects exist at A and B, he has only to take care that the angle measured between them is considerably smaller than that measured at X [73], which may be taken from his chart, to ensure his passing outside its position.

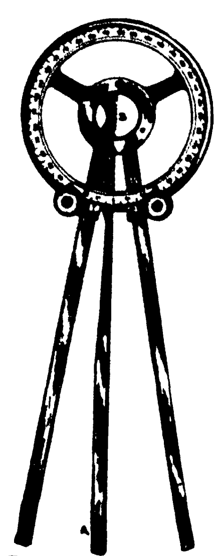
The Three-point Problem. To find the precise position of the boat two angles must be taken [75]. This is called the "Three-point Problem." It is evident that where two circles cut one another is the observer's position, for though he may be at E [74], so far as his angle between A and B is concerned at that position, the angle observed between C and F will not agree, nor will such agreement be found unless the observer is on the circle CDHF. He can only be on both circles at once when he is at D.

Suppose that instead of taking the objects CF to measure the second angle, we take it between BC [75], the observer must be at the point D for the same reasons as in the previous case.

The observations can be plotted by means of circles, or more rapidly by using the station pointer in the following manner. Set the angle ADB off on one side of the fixed arm, and the angle CDB on the other side. Place the instrument on the chart so that the fixed arm is directed to B, move the instrument about on the chart till the other arms fall on the points A and C. The centre (S) of the instrument must then be the required position, and is pricked on to the chart. If the points ABCD fall on the circumference of one circle, the point is indeterminate.

The Lords Commissioners of the Admiralty have issued a pamphlet on the station pointer, which deals exhaustively with the subject.

Soundings must be reduced to a known datum in order to connect the level of the sea-bottom to that of the shore. Soundings of equal values are usually connected together by dotted lines, as in contours on land, the value of the contour being indicated by the dots. Thus, a four fathom contour would be shown by four dots, then a space, and so on Care must be observed in connecting the soundings together, otherwise shoals, or sandbanks may appear on the chart where none in reality exist.



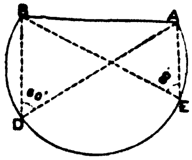
71. STATION POINTER

Foreshore Survey. The survey of the foreshore above low-water mark is carried out in the same way as land surveying. The levelling operations should be extended to, and even below, low water by the staff-holder wading into the sea. The levels so obtained are more accurate than those taken by soundings. Should the work have to be carried out at night, the cross hairs and staff require illuminating, which may be done in the following way: A mirror is soldered to the top of the cap of the telescope in such a position that it projects downwards over the object-glass, making an angle of 45° with the horizontal axis of the instrument. An elliptical hole is cut in this mirror. A lantern supplies the light, which is reflected on to the cross hairs. The staff can be illuminated by a torch, and is thus easily observable through the elliptical hole in the mirror.

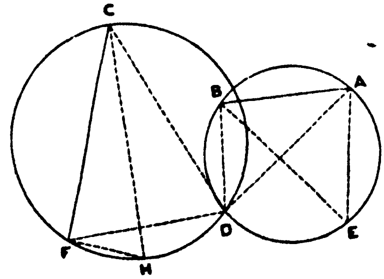
Base by Sound. The length of a base line can be obtained by sound. Although this method is not accurate, it may be employed when only approximate measurements are necessary. It consists in taking the interval of time which elapses between the *sight* of a flash from a gun and the arrival of the *sound*, the observer being at one end of the required base line and the gun at the other. It is preferable to have both a gun and an observer at each end of the line taking alternate readings. The time should be taken by chronometer watches, the beats of which are recorded by the ear and not by the sight, the number per second being thus accurately obtained. The chronometer is held to the ear and the beats counted as nought, nought, etc., until the flash is observed, and then one, two, three, etc., until the report is heard. The mean time of a number of observations, arithmetically obtained, is not correct on account of the acceleration when travelling with the wind being less than the retardation when travelling against it. The following formula must be applied:

$$T = \frac{2tt^1}{t + t^1}$$

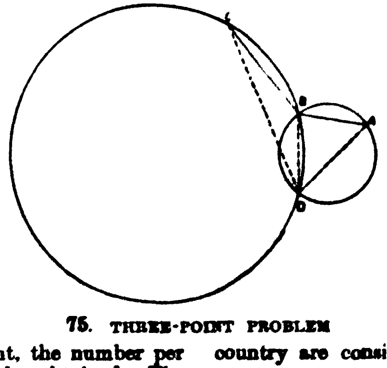
when T = mean interval required; t = interval observed one way; t^1 = interval observed the other way. The mean time (T), multiplied by the velocity of the sound for the temperature at the time of observation, will give the distance between the two places.



72. EXAMPLE 1



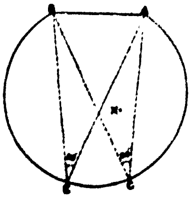
74. INDETERMINATE POINT



75. THREE-POINT PROBLEM

Sound travels at the rate of 1,090 feet per second at 32° F., with an increase or decrease of 1·15 feet per second for each degree of rise or fall in temperature.

Synopsis. The point which we have reached marks a definite stage in our study of civil engineering. This instalment concludes the teaching of Surveying, except for the references which we shall have occasion to make in describing the constructional part. The scheme of our treatment to follow may be indicated. The next article describes the history and practice of the Ordnance Survey, with information regarding the value of the different scales for different purposes. The procedure usual and necessary in seeking to obtain parliamentary powers for public and private works is explained in detail. Then we proceed to study the practice of civil engineering. The course concludes with a description of civil engineering abroad, and the diverse influences, such as climate, labour, transport facilities, etc., which modify the practice from that usual in this country are considered.



73. EXAMPLE 2

Continued

OIL & WATER COLOUR PAINTING

Painting in Oils—continued. **Setting the Palette. Brushes and Painting Ground. Water Colours. Tempera Painting. Fresco Work**

By P. G. KONODY and HALDANE MACFALL

Setting the Palette. We now come to the setting of the colours on the palette. In their order of arrangement artists vary. Some set black at the left end, and run up through the blues, to greens, to browns, to reds, to yellows, to white at the other end [1]. Some put white in the centre, and run off to the right through the yellows to reds and browns, and then run off towards the left to greens, to blues and to black. On the other hand, Whistler's palette was as shown in 2. He considered this eminently scientific. But a far more scientific setting would be to put black in the centre, as in 3.

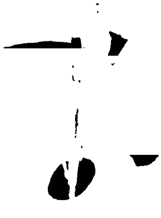
Brushes. The choice of brushes, sable or hog, round or square, is very much a matter of personal taste. Every artist has his own predeliction, which is to a certain extent ruled by his touch. For small work and delicate detail fine sable brushes are indispensable, but the large square hog brush is more useful for the laying on of broad tones, or for crisp modelling on a large scale. A round brush should invariably be used for drawing the outline. The student will soon find which brushes best suit his style, but he should at the beginning have a fairly large assortment of sable and hog brushes of different sizes. The great drawback of the former is, of course, their high price, which is probably the cause of the introduction of hog brushes. As far as can be ascertained, many of the old masters appear to have worked entirely with hair brushes, and it is very questionable whether hog brushes were at all in use before the eighteenth century.

1.

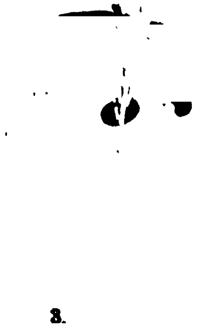
The Painting Ground. Some artists paint on the grey surface of the prepared canvas. Some tone the whole canvas a warm brown. It is with some the practice to mix in the centre of the palette a mass of the general tone of the picture, and to pull each colour through this as they paint, so as to keep the general harmony. But the methods of painting vary with the different schools.

Having sketched roughly in charcoal the general scheme, the artist either paints it in in black and white, or he starts away to paint it "direct." The use of charcoal for the first rough sketch, for "spacing" the composition on the canvas, is, however, avoided by many artists, who prefer to draw the outline immediately with the brush in monochrome, as the charcoal is apt to make the ground gritty. Whenever this method is adopted, it is advisable to do the preliminary "spacing" with charcoal on a sheet of paper, and, when the rough outline of the picture has thus been settled, to copy it on to the canvas.

The method of brushing also greatly varies. There is one school that builds up by careful brushing, there is another school that paints "direct"—that is to say, the brush is charged at each stroke with the true value of colour, and the brushful is then made to draw the form on the canvas in a stroke, and is not again touched or cross-brushed, but left when the stroke is completed. Yet a third school builds up colour with little touches of the three primary colours laid side by side.



2.



3.

Methods. Again, as to the thickness of the paint, some artists paint with the brush loaded with thick colour; others use a full, very moist brush. Each method has its advantages and its drawbacks. The school that paints the picture first in black and white, then runs transparent glowing colour over the modelling, and so employs this "glazing," as it is called, to give colour to the solid painting below it. But this method looks weak beside the forceful, direct method of vigorous paint, such as Velasquez's of old, or Whistler's or Sargent's in our own day. The "direct" painters usually paint the whole canvas at once, carrying forward the picture as a whole each day; the more detailed school paint, say, the head in a portrait first, then paint up the rest to it afterwards.

In painting, the student should always try to get the effect of the volume of air about the object, which gives so much of beauty to its colour values. Faces or objects seen at a certain distance have no hard and harsh outlines, but are seen, as it were, through a veil of intervening atmosphere. The student will easily realise, for instance, what distance gives to colour by putting up a white handkerchief before him, and seeing how white it is against a dead-white object across the room.

Style. The student has now learnt to set his palette, choose his colours, and clean his brushes. He should attack his painting by always trying to get his colour absolutely true, and then putting it upon his canvas boldly, as if he drew with the brush. He will be drawn to express himself after the manner of some particular master, and there is no better schoolmaster for him than the great, whom he should endeavour to rival, and, if it lie in him, to beat.

Each, according to his taste, will be drawn to a certain style. The broad, largely spaced manner of a Brangwyn will appeal to one, with his swinging line, telling masses, and great, wind-filled skies; whilst the extreme delicacy of an Orchardson will appeal to another. The large manner of Paolo Veronese will stir the senses of one with its sense of majesty and grandeur, whilst the solemn dignity of a Leonardo da Vinci will move another, and the decorative charm of a Botticelli appeal to the taste of a third. The broad, masterly painting of Velasquez will teach one the lesson of his art; the Japanese beauty of arrangement, simplicity, harmony, and exquisiteness will enthral another. But whether the student seek after the larger manner, the daintier, or the more exquisite, he should remember above all else that it is by colour, and by the sense of colour that his painting creates, that his art as a painter will eventually be judged—a sculptor by his form, an illustrator by his rhythmic beauty of line.

Painting in Water-colours. In painting in water-colours, the same rules apply as to the choice of colours as in the case of oils, only, perhaps, to a greater degree, for water-colour is used very thin and transparent, and is more easily destroyed by dust and damp. The following list gives a good range of safe colours, but it should always be remembered that the madders are not absolutely stable rose pigments, and that vermilion is liable to turn black.

Ivory black.
Charcoal grey.
French ultramarine.
Cobalt.
Viridian (transparent oxide of chromium).
Light red.
Venetian red.
Indian red.
Rose madder.
Madder carmine.
Purple madder.
Opaque oxide of chromium.
Burnt umber of Cappagh.
Burnt umber of Cappagh brown.
Raw umber.
Burnt sienna.
Raw sienna.
Chinese vermilion.
Yellow ochre.
The three cadmium yellows (deep, orange, and pale).
Aureoline.
Lemon yellow.
Chinese white.

As is the case with oils, there are several water-colours that were much used in the last generation which are more than faulty, if not absolutely bad. Gamboge was a villainous yellow, and Hooker's green, sap green, indigo, Prussian blue, Antwerp blue, Vandyke brown, and sepia, all fade with time. The chrome yellows are detestably bad, and injurious colours to use, as well as the beautiful emerald green, Naples yellow, orpiment, and the lakes. Red lead, also, is death to other colours.

The colours for water-colour painting in pans are better than those in tubes or dry cakes. The pans being moist, yield up their pigment easily and quickly—a very important matter in water-colour painting, and still more important in sketching. The best box to hold these "pans" is the black tin water-colour box sold by the artists' material dealers, with a place for the brushes, and flaps for use as palettes.

As regards white, the artist should be careful to avoid all whites that contain lead, as these turn dingy and end in absolute blackness in quite a short while. The best white to use is pure *Chinese white*, which is not only quite permanent, but has the additional merit of preserving good colour when bound with it.

As regards black, the *charcoal grey* used by black-and-white artists is a beautiful black, yielding exquisitely pearly greys and deep velvety darks. Indian ink is a brown black, and can be washed over. Lampblack is a deep, strong black.

Brushes and Painting Surface. A very few brushes, if good ones, will last for years. Three or four black or brown sables of varying size are all that are required; indeed, one good medium-sized brush will give all degrees of point necessary, if one also have a flat "camel-hair" for laying in broad washes, or for moistening the paper.

In water-colours the effect of the washes depends greatly upon the surface on which they are placed; the white paint in oils is, in water-colours, replaced by the white ground on which the more or less transparent washes of colour are dependent for their tone. The best paper is white, and should be strong and smooth in surface, except where rough surfaces suit the particular handling of the individual artist. The Old Water Colour Society's paper is the best in the market; whilst several firms also provide good hand-made thick *linen papers*. Before painting on a paper it is always best to run a wash of very slight tint over the whole; this will betray grease-spots and mildew, and the best way to get rid of them is to avoid the paper that betrays either.

The old-fashioned system of stretching the paper on a drawing-board is now almost superseded by the use of "sketching-boards," the paper being pasted down to cardboard, and saving infinite pains and trouble. The student should avoid tinted papers, and learn to use the white ground, to yield him the beauty of translucency which is so valuable in water-colours.

It should be remembered also that very often when the colour does not run easily upon the paper it may be the fault of the hardness of the water. In this case distilled or boiled water will make all the difference.

If the paint in the pan goes dry, a little warm distilled water will soften the hardened gum of the pigment, if left to soak.

The Choice of Colours. Now, with his colours, his brushes, water, and good white paper, the student is ready for work. With a pencil he sketches in the main lines, and then proceeds to wash in his masses. He has to choose between the two schools of water-colour painters—the Transparent Colour School (or purists) and the Body Colour School.

The purists do not use opaque colour, and, above all, will not allow the use of Chinese white in their washes. The body-colour men use white floated through their tints, and also use opaque colours solidly. The former is unquestionably the more legitimate method, and the student would do well in the beginning strictly to avoid all opaque colour. The true beauty and value of water-colour lies in its luminous transparency, and this is lost by the use of body colour.

The colours, whether solid or transparent, may be used broadly in washes to give broad effects, or they may be used minutely in what is called stipple, to give minute detail. But to whatever school of painting the artist may belong—the transparent, or wash school, or the body-colour school, the broad, impressionist school, or the stippled, detail school—there are certain laws that apply to all. He should wash in his background at the same time that he paints his main objects, so as to give those objects their full value; otherwise he will find that the white paper of the background has forced the value of his objects, so that when he tones down that background the objects look poor and weak.

Some Hints. The student must, as in oil painting, master the simple rules of perspective, and, if a figure painter, master anatomy.

Remember always, in painting in the open, not to paint your sketch at all hours of the day. Go back and paint under the same conditions of time and sunlight.

Master the rapid making of greys with, say, light red, cobalt, and yellow ochre, and so on.

It is always wise to wash in your backgrounds first; then you have not the ugly tendency to get your main objects out of their atmosphere.

Here, again, as in oils, let the student study the masters of his craft—the old men like the grand master Cotman, and the great men of to-day like Sargent. Look what Sargent and Brangwyn can do with their broad, sweeping masses, knowing exactly where to place them. Randolph Caldecott, again, is a fine master to teach the value of broad washes. Let the student haunt the exhibitions also, and study day after day the work of men he admires, and try, when he gets home, to rival them from memory. Melville's work is very masterly and telling.

In painting, brush in the mass of a thing first; and with a full brush, or a brush charged with clean water, fill in or take out detail as you want it.

Cotman of old, and Sargent, Whistler, George Clausen, Charles Green, Crawhall, Alexander, Pryde, and the like to-day all have lessons to teach us. But do not *copy* too much. A few copies from one master should never be exceeded. Master their methods, and use them to help the style you wish to evolve.

What will trouble the student much in water-colours is the hardness of his edges. He can, and should, avoid this by damping his paper *slightly* before painting upon it.

Methods of Working. Perhaps it will be some guide to the student to give the method of working of one or two of the great English painters.

David Cox's manner of painting was simple in treatment. He only used the barest pencil outline—often none at all. He then washed in his masses with many superimposed layers of colour, beginning with a ghostly picture of the landscape, and building it up as a whole, always keeping his work transparent and pure in values, and most carefully preserving the sense of atmosphere throughout. His drawings have a resulting effect of facility and freedom of labour and from heaviness that make his work a great achievement. He unfortunately used a wretched palette—gamboge, lake, Prussian blue, indigo and sepia, being amongst his twelve colours. He spoke passionately against the use of white in water-colour work.

The "Wet Manner." Prout outlined his work in brown ink and tinted in the whole.

De Wint painted boldly in the "wet manner," saturating his paper with water, and then floating on to it his colours in a full brush whilst the paper was quite wet. He never interfered with his masses afterwards. He used two large brushes, one with a fine point, the other round and blunt. He, too, unfortunately used amongst his nine colours such wretched pigments as purple lake, Prussian blue, indigo, gamboge, brown-pink and sepia, and his reds killed the blues as time wore on. He only used white, and that for his lights, towards the end. In his best work he "left out" the lights as pure white paper.

Whistler ran Chinese white through nearly every wash; and achieved such atmosphere as it would be difficult to surpass. Yet he was so incapable of using pure wash that when trying to paint on ivory he gave it up, because the white would get in, and the value of the underlying ivory was thus lost. Sargent uses water-colour in big washes of pure colour, using white only to enhance the high lights.

Long before the invention of oil painting, with which the brothers Van Eyck are generally credited, artists in Italy and in the North practised another method, which, after having been neglected for some centuries, has lately come once more into favour, though the practice of this art of *tempera painting* is still confined to a comparatively small group of artists. Fortunately, Cennino Cennini, an early 15th century Italian painter, has left us a treatise on painting, in which all the methods in use at his time are technically described. An admirable translation of "The Book of the Art of Cennino Cennini," by Christiana J. Herringham, which has been published in an inexpensive form by Mr. G. Allen, is accessible to every student, and will be of invaluable help to anybody who wishes to master the technique of tempera painting.

Tempera Painting. Cennini has well defined the nature of tempera painting. "It is true," he says, "that pictures are painted just as I explained to you to work in fresco, with three exceptions. One is that you must always paint the draperies before the faces. The second is that you must temper your colours always with yolk of egg, and thoroughly tempered, always as much of the yolk as of the colours you temper with it. The third is this: That the colours must be ground very fine—well ground—just like water." Tempera painting is thus painting with yolk of egg as medium. The advantage of the method lies in the transparency and purity of the colour, which cannot be rivalled by oil-paint. Moreover, tempera colour is permanent, and not subject to chemical processes of disintegration. Most of the tempera pictures of the early Italian and Flemish masters have preserved their pristine bloom and freshness to the present day.

On the other hand, tempera is a most difficult medium to handle, and will never yield the depth of shadow which can be obtained by oil-colours. It requires very precise drawing, because corrections are difficult to make; while delicate gradations, such as can easily be produced with oil-colours, are practically impossible to get with this method. Tempera can only be recommended for decorative work in more or less flat tints. It is almost useless in the hands of the modern painter who aims at realism, at the life-like, plastic appearance of things, and at atmospheric effects. Tempera colours could produce a Botticelli, but never a Rembrandt.

Surface. The best surface for tempera painting is offered by wood panels, which can be bought ready for use from artists' material dealers. Since a demand has sprung up, various preparations of tempera paint have been placed on the market, but it is best to follow the example of the old masters and prepare one's own material. An immense amount of disappointment will be saved by a judicious selection of the wood required for the panel. If possible, this should be old, well-seasoned oak. The planks of old boats are admirable for this purpose, as they are not likely to warp.

To guard against any action in the wood, the back of the panel must be specially strengthened by strips of wood criss-crossing, and fixed so firmly to the panel that it is impervious to the injurious effects of heat or damp. The next step is to make a preparation, with which the wood is covered to get a delicate surface for the tempera paint.

Take a quantity of plaster-of-Paris and leave it to soak in a tub of water for two or three months. This is to destroy the life in the plaster, which is liable to ruin the colours if the mixture is used too soon. The preparation should be stirred well every day for a few weeks. Then the water can be poured off, and the plaster rolled into cakes. These are the balls of *Gesso*, ready for further preparation.

The Method. This gesso is ground to a powder and mixed into a smooth paste with water. Melt some carpenters' glue, and while it is boiling pour it into the gesso paste, which must previously be warmed to prevent the glue from thickening immediately. The paste and glue have to be well stirred together. There is an easy method for finding out whether a sufficient quantity of glue has been added. Pour a little of the mixture on to a piece of paper and dry it over the fire. Moisten the finger and rub the gesso; if any white comes off on the finger, it is a sign that the mixture does not contain enough glue.

It should be remembered that glue can always be added, but that it cannot be taken away from the mixture. It is advisable to give the panel a preliminary coating of glue, but this is not absolutely necessary. Apply the gesso, while it is rather stiff, with a brush, and spread it evenly over the surface—not too thickly, but it should not be transparent—and leave it to dry. When the preparation has become hard, rub the surface down with fine sandpaper to a convenient degree of smoothness. This is, of course, a matter of personal taste. If the tempera is laid on too thickly, it is liable to chip at the sides.

Dry Ground. To prepare the tempera for a dry ground, take only the white of an egg, mix very stiffly with the powdered earth colours that colourmen sell. The medium to use is the white and the yolk of egg beaten up, and mixed with a little water, or, better still, only the white of egg and water. The great advantage of tempera over oil is that it dries almost immediately. It can be used on canvas, or even on paper, but the most delightful effects result from its being applied transparently on the gesso surface.

In many of the masterpieces of the greatest workers in tempera it will be seen that many of the small details of the picture are raised in relief, such as the crowns and the halos of saints, or the embroidery on the richly decorated garments. There are some very remarkable examples of this raised work in our National Gallery, notably some of the pictures by Carlo Crivelli. This moulding is all executed in gesso—that is, in the substance which has already been described as a suitable basis for tempera painting. Only, for relief work it is made with less liquid and more glue, and applied very stiffly with the brush, layer above layer, until the desired relief is obtained. Then, when the artist is satisfied with the plastic shape, the surface is painted and gilt to get the desired pictorial effect. This method has been successfully revived in recent years by some Birmingham artists, who have produced some delightfully quaint and effective caskets, chests, and other decorative objects in mediæval taste.

It may be useful to the artist to know that fairly reliable tempera colours can be obtained from a German firm in Düsseldorf, who have made a special study of this medium, and who have issued a catalogue in which the colours, which are guaranteed to be absolutely permanent, are specially marked.

Fresco. Fresco painting is the term applied to paintings executed on a wet plaster ground, for which purpose tempera colours are generally used. In fact, fresco work is the ideal application of this difficult medium, since large decorative mural paintings should accentuate the flatness of the wall rather than deceive one into believing that the wall opens to reveal a glimpse of real life and nature; and this deception, which is one of the chief aims of most modern painters, can only be achieved with oil colours.

The Italian masters of the fifteenth century were the ideal decorative painters. Painting direct on the wall of church and cloisters and palace, they were forced to consider the surroundings, and realised that wall painting should have no independent existence, but be the handmaiden of architecture. Many modern painters do their decorative work in the studio without thinking of its ultimate destination. The result is that when the canvas is fixed in position on the wall, it probably looks incongruous and detracts from, instead of adding to, the effect of the architectural setting. But a great improvement has lately set in in this direction, and we have now a few artists who, like Frank Brangwyn, are fully appreciative of the exigencies of decorative work.

The First Consideration. The first technical consideration should be the surface of the wall chosen, which must be specially prepared. Procure, in the first place, the necessary quantities of lime and sand, according to the space that has to be covered. Sift both, so that they are entirely free from lumps. If the lime is very fresh it will require the addition of twice its quantity in sand. Mix these materials with water, and allow the lime to rest for some time to avoid the risk of bad cracks when the plaster is dry. The surface on which the fresco is to be laid must be well cleaned and drenched with water. Having thoroughly stirred the lime and sand, spread it evenly, in one or two applications, on the wet surface until the mixture itself settles to form a new, flat ground.

That this flat surface should be rough in grain is an advantage. This quality is obtained by mixing the mortar with as little liquid as practicable. In a few hours the preparation will be dry and ready to receive the artist's first design, which should be in charcoal, as any false lines in tempera paint would immediately become one with the plaster, and therefore ineffaceable. When the drawing is correctly executed in charcoal, the outlines should be drawn in with ochre or sienna, and the charcoal brushed away with a feather brush. Before the actual painting is begun the mixture of lime and sand must be repeated. It is *most* important that the whole picture should be painted while the plaster is wet, so that the paint and plaster amalgamate, become absorbed into each other, and make one perfect whole, which should withstand the attacks of time and weather. From this painting on a fresh plaster ground the whole method has received its name—the word *fresco* being Italian for fresh.

Surface of the Plaster. Since it is impossible to paint at once over the whole surface, the artist must spread this second mixture of lime and sand thinly over just the amount of wall space which he can cover with paint in one day. Having already marked the first simple outlines of his picture, he should follow these, filling them in with the wet plaster, so as not entirely to obliterate the skeleton of his design. Every day another portion is thus added, until the whole picture is completed. It cannot be insisted upon too emphatically that the essential point in fresco painting is the wetness of the plaster which receives the paint. This second coating of plaster must be applied lightly, and for this purpose a brush of hog-hair should be used, steeped in clear water, and the mortar wetted with it. A strip of wood as broad as the palm of a man's hand is passed over the surface to remove any surplus plaster and to distribute it quite evenly over the section chosen for the day's work.

In case of any accident or change in the design, the faulty part must be soaked off bodily, painted and plastered together, and a fresh surface created. From this it will be seen how important it is that the first design should be quite correct, as a small fault requires such drastic correction. The medium for this fresco work is a special form of tempera, which can be made by the worker himself.

Beat up the yolk and white of one or two eggs with water. The paints used in fresco are the powdered earth colours obtainable from all colourmen. This powder must be made into a thin paste, well mixed with the egg and water. When being applied to the wet plaster, the paste must be still further diluted, so that it may mingle and become one with the ground. Once more the necessity for wetness in the plaster and liquidness of the paint must be insisted upon. For fresco painting on canvas the method is the same.

Continued

A SURVEY OF FLAX, HEMP AND JUTE

The English, Scotch, and Irish Linen Trades. The Manufacturing Processes Reviewed. Canvas Floorcloth and Linoleum. Rope Spinning

Group 28

TEXTILES

7

Continued from page [illegible]

By W. S. MURPHY

LINEN cloth has always been held in high esteem by cultured nations.

It was not till the tenth century that the linen industry of Europe came into historic prominence, when the Flemish town of Ypres became prosperous and important on its linen manufactures, the speciality of which was a fine cloth, since called *diapers* among ourselves, an evident corruption of "d'Ypres."

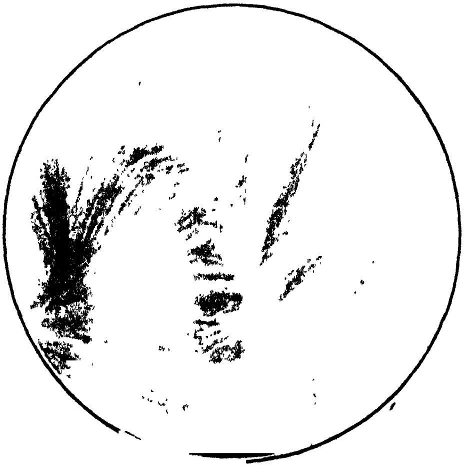
British Linen Manufacture. The first mention of Irish linen occurs in the thirteenth century. In Scotland the trade must have been important about the same period, because the bodies of the Scottish foot soldiers unearthed in the last century on the field of Bannockburn were clad partly in linen. The large trade of England, being carried on in each little parish for local consumption, totally eludes observation before the year 1720, when the fibre appears as the universal provider of warp for cotton, which could then be spun only for weft.

At present there are four important centres of the trade—*viz.*, Belfast, Manchester, Leeds, and Dundee.

Just at the time when cotton was coming to drive English linen out of many markets, the rival fibre stimulated for a short period the production of linen yarn. Up till the year 1773, cotton could not be spun strongly enough for cloth warps, and linen was used.

During the latter half of the seventeenth century, the Irish linen industry, quietly practised for centuries in the Ulster province, received a fresh impetus from the invasion of skilled weavers of cambrics from Picardy, driven thither by the Revocation of the Edict of Nantes.

Lisburn, Ballymena, Armagh, Coleraine, and Lurgan were the chief centres of the linen industry, and to these towns Belfast is the nearest great seaport. Having a fair share of the industry itself, Belfast became naturally the emporium of Irish linen. When the factory system began to supersede hand-production, mills were built in Belfast, and the seaport quickly attained first rank as a linen manufacturing town.



31. FLAX FIBRE

As we have already indicated, the linen trade of Scotland is of old standing. Two of the principal centres of the industry are Dundee and Dunfermline, the former in the coarser linens, and the latter in damasks and diapers. The history of the Dundee linen trade strongly resembles that of Belfast.

About the close of the seventeenth century, a small colony of Huguenot linen weavers had settled in Edinburgh, on the spot now known as Picardy Place. Some of these weavers migrated to Dunfermline, helping materially to establish that reputation for damasks and fine linens which Dunfermline still enjoys.

The Manufacturing Processes. In many respects, with all our progress, we have not advanced beyond the methods practised five thousand years ago. The spinning wheel which we illustrate [82] by a picture lent by Messrs. Bannerman & Sons, Ltd., Manchester, contains the principle of flax spinning, and all our machinery is little more than an elaboration of that contrivance. Our young men have plenty of scope for their ingenuity in the improvement of linen manufacture. The process is a long series of graded operations. We will take up each stage of the process in detail, but a short summary may be given here.

1. *Retting* frees the fibre from the rest of the stem.
2. *Scutching* breaks off the woody substance still clinging to the fibres, and tends to open them out.
3. *Roughing* gives the fibres a preliminary clean, sort, and range.
4. *Hackling* combs out the fibres, separating the short from the long.
5. *Sorting* classifies the fibres.
6. *Spreading* is a kind of rough carding, which lays the fibres alongside each other, and forms them into a sliver or soft rope.
7. *Drawing* lengthens out the slivers and gives them the form of thread.
8. *Roving* continues the last process, and prepares the thread for the spinner.
9. *Spinning* refines, twists, and forms the thread by means of successive machines.
10. *Reeling* winds the spun yarn into hanks.

11. *Winding* forms the spools of weft for the shuttles of the loom.

12. *Warping* lays the warp yarn on the dressing or weaving beam.

13. *Dressing* coats the thread of the warp with size, to strengthen it for the weaving.

14. *Healding* sets the warp in position for weaving on the loom.

15. *Weaving* unites warp and weft in cloth.

16. *Bleaching* whitens the cloth.

In addition, we have to see the flax fibres made into thread for lace-making and sewing. Many of these processes are almost identical with some of the processes in cotton, wool, and silk manufactures ; and while the linen industry must always be studied as a distinct entity, the plan of our course has been arranged so that all the textile workers having a common interest in any machines or methods may study them together.

The linen manufacturer produces a vast range of goods—from the lightest of cambrics to the coarsest of canvases ; from the plainest of sheetings to the most beautiful of damasks and brocades ; and from the finest of lace threads to the strongest of cables. This brings him into close competition and association with the workers in hemp, jute, and other fibres of that class.

Jute Manufacture. So closely related in treatment and product are all the best fibres that it is almost a pity they are not united as one industry. We can hardly say, however, that a lad who has been taught the linen industry is, on that account, equipped for work in a jute mill in all its departments. In actual fact, reasons historical, economic, and industrial forbid that desirable event, and we must meanwhile take things as they are.

Softening. The retting, scutching, and baling of the jute fibre take place in those tropical lands where it is grown—at present, almost exclusively India. When we receive the jute fibres they are fairly clean, long, and lustrous ; but we also find them harsh and brittle. For more than half a century these defects hindered the development of the jute industry in this country. As has been already stated, the problem was solved by the invention of the softener. The bales are opened out, and the fibre formed into *stricks* or *strikes* by the attendant on the softening machine, or his helper.

A vast combination of fluted rollers and oil-distributors, ingeniously devised, the softener delivers the fibres in a condition equal to flax in flexibility. Thence, jute follows a process of manufacture similar in its main details to that of flax, already detailed.

Jute not only rivals flax for many purposes, but it also has a department almost to itself, worthy of special note.

Floorcloth and Linoleum. Floorcloth was originally invented by Nathan Smith, in 1763, and patented by him as a substitute for carpets. He must have been something of a poet and hygienist this Nathan Smith, because there was a curious mixture of sentiment and sanitation in his idea. Jute was not known at that time. Mr. Smith's idea was to use the flax fibre and the flax-oil—linseed-oil—for the production of an ideal floorcloth, thus utilising all the product of the plant in one fabric. Jute, as the bulkier, softer, and cheaper fibre, displaced flax in the body of the floorcloth, but the method of manufacture remained practically the same.

Floorcloth is a canvas saturated and covered over with paint. Paint is a dry colour mixed with some kind of oil, and as linseed-oil is a quick drier, it is well suited for the floorcloth manufacturer's purpose. Each coat of paint must be dry before the next is laid on, and if the paint did not harden quickly, the process of manufacture would be tedious and costly. The process of manufacture is very simple. The canvas is primed—that is, coated back and front with size. The size is scoured smooth with pumice-stone, and then the thick linseed-oil paint is applied thickly, and spread smooth with a trowel. After drying for 12 or 14 days, it is smoothed well with pumice-stone, and coated with paint as before. The back is now solid ; a coating of size is applied to the front side of the canvas, which is treated in the same manner as the back. For high qualities as many as four coats of paint are laid on the right side of the cloth. In this condition it is plain, and by giving it a coat of varnish we might send it out as plain floorcloth. But the common taste demands some kind of ornament. We therefore proceed to print on the surface a pattern or design, by means of paint-covered blocks, which leave the coloured lines and masses standing out in relief. When sufficiently dry, it is varnished over, and again dried.

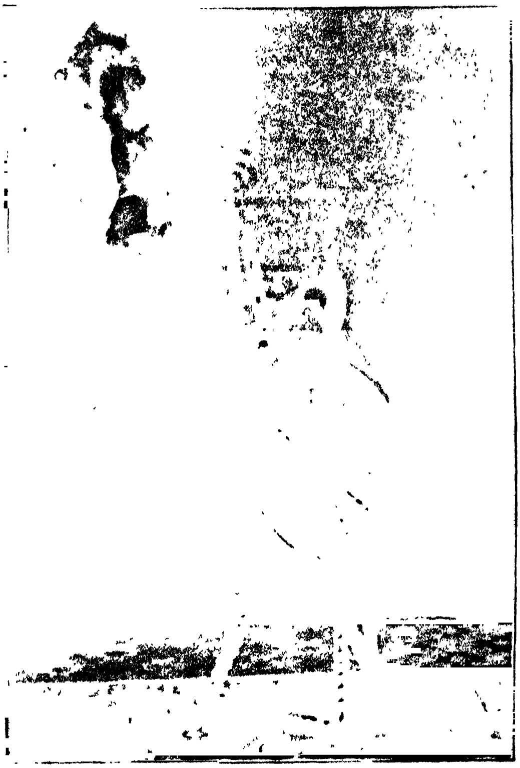
Such is the old-fashioned process of floorcloth manufacture. We shall, when the whole process is being studied in detail, show the various improvements made and machinery used in the modern factory ; but, in the main, the methods are the same.

Cork and Improved Linoleums. Though floorcloth had many merits, it failed in competition with carpets because of its hardness, coldness, and lack of sound-deadening qualities. This led to many attempts being made to produce a softer cloth of similar manufacture. In 1844 Elijah Galloway took out a patent for a fabric he named *kamptulicon*, made from ground cork and indiarubber, amalgamated by the action of heated rollers. This fabric attracted considerable notice when shown at the Exhibition of 1862, and several factories were started for its manufacture. It was used in many great public buildings, notably the Houses of Parliament ; but the materials of which the fabric was made rendered it costly, and beyond the reach of all but the wealthy classes.

In 1860 Mr. Frederick Walton conceived the idea of making a substitute for indiarubber from linseed oil, and three years later took out a patent for the application of this material to the production of floorcloth. By melting oxidised linseed oil with kauri gum and resin, mixing the mass with ground cork, and rolling the material thus obtained on a canvas back, a floorcloth was manufactured quite equal to Galloway's fabric, and much cheaper.

The new floorcloth was named *linoleum*, and had some success, as well as rivals, most notably the fabric called *corticine*, made by a similar process, but discovered independently.

Later developments in linoleum manufacture have chiefly been in the direction of rendering permanent and artistic the patterns and designs popular taste demands on floor coverings—whether composed of floorcloth or carpet. The stages of the progress linoleum manufacturers have made in this direction are interesting. As is well understood, a merely surface pattern quickly disappears from linoleum under the tread of many feet. To give an indelible surface, Mr. Walton devised a cork covering composed of different coloured granules, imposed on the canvas and pressed with heated rollers, producing granite pattern. Next, the cork covering was made up of small pieces, coloured to form a design, and impressed on the backing, the result being a kind of mosaic. This, however, lacked the plasticity demanded by art, and other attempts were made, bringing out two methods of inlaying—one called the "grid," and the "other the "stencil." In the one, the small pieces of differently coloured cork composition were definitely moulded; in the other, they were coloured by a stencil process. The former, it was claimed, gave clearer outlines; but for the other, the merit of softer effects was asserted.



32. SPINNING WHEEL

Ropes and Twines. If antiquity or primitiveness be a merit, the ropemaker should take a high place. The art of spinning is merely a making of ropes; weaving is the plaiting of cords. Most probably the first of the textile industries, ropemaking was certainly the last to be noted by the inventor and the capitalist. Carried on in small country villages, or in the back streets of seaports—for purely local consumption—ropemaking was scarcely recognised as an industry till the beginning of the 19th century. Yet in the days before the steamship ropemaking was one of our greatest imperial assets; on the strength and toughness of her shrouds and cables the safety and power of the ship depended. Southey tells us that Nelson, just after he received his death-wound, observed that the tiller-ropes of the Victory had been shot away, and ordered new ones to be rove. Woolwich Arsenal originated from the ropery in which cables and sail tackle were made. All round the coast for centuries the ropemakers and net-makers have plied their useful craft; but they made for home and local consumption only, and therefore did not come within the purview of the statistician, the wealth they created passing unnoticed into the coffers of the Empire.

Scope of the Industry. Twine and ropemaking is an industry which extends much farther than most people are aware; it includes bootlaces, staylaces, and window - blind cords; twines, nets, lines, and netting; pulley-ropes, driving-ropes, crane - ropes, cables and hawsers; wire ropes, of steel, iron, brass, and copper, and many small specialities.

Materials Used. The rope factory is the last resort of textile fibres rejected by the spinners of cloth yarns. Ropemakers have no reason to object to this, because the practice has brought to the industry many very useful and cheap fibres. Our raw materials comprise nearly all the vegetable fibres, the sole condition of use required of any fibre being cheapness and suitability for either general or special purposes. In addition, ropes are made of iron, steel, brass, and copper. Paper and glass could be utilised, and might serve special purposes very well, but these materials have not yet been employed to any extent.

Roperies. Primitive in its origin and essential character, the rope industry did not attract the machine inventor for a long time Up till near the close of the 19th century the rope-spinner might have been seen working on the open fields, in agricultural districts remote from railways and the tracks of traffic. A lone figure comes walking backwards across the field, lengthening out a strand of rope at every step, while at the far end a lad is working a whorl, in the hook of which the end of the strand is fixed. From round his waist the man draws wisps of hackled hemp, and keeps twining it on to the strand, feeding with one hand, and with the other holding and regulating. We need hardly observe him further, for that man has been practically unemployed several years.

When rope-spinning ceased to be an open-air industry, largely dependent on weather conditions, the path of the spinner was roofed in, and named the rope-walk. Here, under shelter, the work could go on all the year round, and machinery could be used. The simple whorl, with its single hook twining one thread or strand, became a wheel driving many whorls, each one giving work to a spinner. Then spinning machinery grew up outside, and came in to change the function of the ropemaker altogether, or at least in great part. Where first-class and special ropes were wanted, the old rope-walk was retained, and the spinner continued his old way; but alongside, another rope-walk was built, and on the middle path rails were laid, along which ran an automatic spinner, called a traveller, twining the threads into strands and the strands into ropes.

33. JUTE SLIVER

Where the old shed of the ropewalk stood, a new factory, filled with spinning machinery, now stands, and it also tends to grow. Add on to the twisting and reeling departments twining and balling machines, for they are merely adaptations of the same principles. Next, the steam engine, or the electric dynamo, having come as our motive power, we construct rope-laying machines, vertical and horizontal, in which the principle of the twister has been adopted on a large scale. As an adjunct to these, the closing machine, similar in construction, but simpler, is installed, and our rope and twine factory is complete.

Still extending our industry we add on a wing to the twine-spinning side, and therein instal machines for netting and plaiting, where fishing-nets and lacing bands of all kinds are made. On the rope-laying side we may build another wing, and form a wire-rope department. Provided we possess the capital, the wire-rope venture involves no difficulty. Our machines are simply hempen rope-laying machines, only heavier and stronger.

Principle of Rope-Spinning. Many an observant man has, no doubt, wondered for a moment at the firm consistency and solid structure of a rope. So far as one can see, there is no reason why the strands of a heavy cable should hold together. Weaving plaits weft and warp into unity; but the threads of the strands of the rope have been merely twined round each other by an impulse or force which must gradually lose its effect. According to rational expectation, we ought to find some day our rope slowly uncoiling and resolving itself into its original fibres. It is this tendency to uncoil which constitutes the unity of the cable.

Every effort those little fibres make to free themselves from each other binds them more tightly in the larger unity.

If we try to break up a cable by loosening the strands and threads, we have against us the natural effort of the fibres to free themselves. A cable dies, not because the natural force in the fibres has been too strong for man's art, but for the opposite reason—viz., that the fibres have ceased to struggle, have lost the power of resistance. That is why a new rope is stronger than an old one of the same quality.

Summary of this Course. Our study of textiles up to this point has been a broad review of the various trades engaged in it, and a consideration of the raw materials used, their sources of supply, and their cultivation. In our next issue we begin a study of fibre treatment- and proceed later to consider the manufacture of yarns, the processes of weaving, and special manufactures, such as felts, carpets, hosiery, and laces. Attention is given in its proper place to the preparation of artificial fibres, which constitutes one of the most marvellous applications of chemistry in modern industry. The concluding section is a comprehensive digest of the modern practice of dyeing, which seems every year to remodel itself and take advantage of the latest discoveries in synthetic chemistry.

Continued

AGENTS OF HUMAN EVOLUTION

Continued from page 778

Evidences of the Working of the Agencies of Evolution. Effects of Disease in Evolution. Immunity. Geological Evidence

By Dr. GERALD LEIGHTON

The Survival of the Fit. We may well believe that in the ages that are gone, when man was a primitive savage, the conditions which determined his survival were widely different from those acting upon the civilised man of to-day. The laws of their application were doubtless identical, the actual conditions different. Survival in those periods depended mainly upon physical strength and activity, great powers of bodily endurance, keenness of vision, and the other qualities which we associate with the life of the savage. Violence and privation were then active agents of selection, and those best able to withstand them survived.

But the case is different to-day. These conditions are no longer selective in civilised lands. The weakling, the stupid, or the blind, if born in a superior position, has a better chance of survival than many a stronger individual born to poverty. Selection along the old lines has ceased, the race is not necessarily to the swift nor the battle to the strong. But this does not mean that selection is no longer going on. Individuals do not, even now, all live to old age, or even to maturity. Immense numbers still perish both before maturity and during the time of their ability to have offspring. There is still a tremendously powerful agent of selection at work amongst civilised men, or amongst those who come into contact with him, and that agent is *infective disease*. In most countries infectious diseases are so prevalent that no individual escapes infection unless he be immune, nor death unless he has some degree of resistance.

The Causes from which Men Die. The only way in which we can find out the direction in which a species is evolving is to observe the characteristics of those individuals that perish, and compare them with those of the survivors. We thus discover the traits which determine survival.

This is the precise difficulty with plants and animals in nature. Their deaths may be due to any one of a number of causes acting upon some individual deficiency of which we are entirely ignorant. Most plants and animals are destroyed by some agency or other before maturity. Only a few, *even of the fit*, are allowed to survive. The majority of the deaths amongst them are probably haphazard. It was this fact which doubtless caused Lord Salisbury to deny the existence of natural selection.

But we know man much better than any other animal or plant. The peculiarities of every human being are, of necessity, noted before his death by some of his contemporaries. His offspring and descendants are also under close observation. For some thousands of years the chief causes of mortality among his races have been studied with anxious attention.

During recent years very precise scientific methods have been adopted. An army of trained and experienced medical workers has delved in almost every nook and cranny of the world, and in all civilised countries a Government department has tabulated the results of their labours. We know now precisely the causes from which men die, we know approximately the number of deaths due to each cause, and the average ages at which men die from this or that cause. We have, therefore, ample materials on which to found a judgment as to the effects produced on descendants, and, therefore, on the race, by these precisely ascertained and tabulated causes of elimination.

Haphazard Deaths Rare. "In the great majority of instances," says one writer, "men, especially civilised men, perish of disease. Haphazard deaths, comparatively speaking, are very rare. Moreover, where men live in dense and settled masses, and so can take disease from one another, the great majority of deaths are due to zymotic diseases—to diseases caused by minute living organisms.

"If ever natural selection has been at work, we should see its processes demonstrated by the familar causes of death among the living beings we know best. It is universally admitted that men differ greatly in their susceptibility to infection and in their powers of subsequent resistance. If, then, a lethal disease be very prevalent, it is evident that it presents a very stringent form of natural selection.

"In England, for example, hardly anyone escapes measles, whooping-cough, or tuberculosis, unless he be immune, or death unless he be resistant. Whenever any form of selection is stringent, it is accompanied by an evolution of those qualities which enable the survivors to escape. It follows, in the case of disease, that selection should cause an evolution of an inborn power of resisting infection, or of an inborn power of recovering from infection. The two qualities are quite distinct. They are also useful against quite distinct diseases."

The Two Kinds of Disease. We may regard diseases in this connection as of two kinds:

1. Those against which the patient can acquire some degree of immunity by recovery from an attack; for example, smallpox, measles, scarlet fever.

2. Those against which no power of resistance can be acquired by the individual.

Now apply the theory of natural selection of those individuals that are best fitted to survive, and observe the result. Note that though one attack of disease of the first kind usually confers individual immunity, yet in such cases the *race* never attains to immunity. Each succeeding generation remains susceptible as to infection as the preceding one. Thus Englishmen who, on recovery from measles, are individually immune, have offspring who are as susceptible to infection as were their parents.

Immunity. This happens in spite of the fact that individual Englishmen have acquired immunity from attacks of measles in childhood, and that this has gone on for generations. But measles is an agent of selection. It eliminates and weeds out those who cannot acquire immunity against it, and therefore the direction the evolution takes is towards an increase of the *power of acquiring* immunity. That is to say, those individuals which had inborn in them the greatest resisting power are the fittest to survive in that particular environment, and do survive, transmitting their inborn resistance to their descendants, the result being that the race increases its power of acquiring immunity against measles, which, therefore, in time becomes a comparatively trivial disease for that race.

But if measles be introduced into a new environment—for example, among a race such as the Polynesians, who have had no previous experience of it, amongst whom there has therefore been no selection of the fittest in this connection—what is the result? The disease may wipe out a whole tribe. There has been no opportunity for natural selection to evolve the power of acquiring immunity. For that reason, though Englishmen are as susceptible to infection by measles as Polynesians, they recover from it much more easily.

Consumption as a Factor in Evoluton. On the other hand, observe what has taken place with regard to those diseases against which the individual is unable to acquire a personal immunity, such as tuberculosis. Look again at the human race. For hundreds of years consumption has ravaged the Old World, and more especially the crowded parts of it, such as England. But Englishmen now increase in towns and crowded cities, the natural breeding-place of consumption.

Under similar conditions of life the natives of the New World, where until recently consumption was unknown, perish. When they are infected with consumption from white men they tend to extinction even in rural districts, not to mention in cities. Plainly there has been a great evolution, but as plainly it has resulted from the survival of the fittest by natural selection, and not from the transmission of any acquired characters.

There has been an inborn immunity evolved in this case as the result of long exposure to the selecting agency of the disease. So the Englishman has evolved his capacity to resist the infection of consumption and to gain the power of recovering from an attack of measles. The argument applies equally to animals other than man, and to agencies other than disease.

In the face of such facts as the foregoing it is impossible not to recognise the existence of the principle of natural selection, and we may proceed to note briefly other objections which have been brought forward against Darwinism.

The White Ruler of a Black People. The swamping effect of intercrossing has been regarded as one of the most formidable difficulties of the Darwinian theory. According to this objection, even where a very advantageous variation occurs in offspring, it would seem that this is just as likely to disappear in succeeding generations as to persist and be selected. It would tend to disappear as the result of intercrossing. It was urged that the same variation does not occur simultaneously in a number of individuals inhabiting the same area, which would be necessary in order that the variation might be handed on by heredity.

The difficulty is illustrated by the hypothetical case of a white man becoming the ruler of a black population, his whiteness representing the advantageous variation. As the result of his mating with a black woman his offspring would be yellow, and in course of time the variation would be swamped by intercrossing and the royal family would be black again.

This objection has been met by the supposition that the advantageous variation does occur in a sufficiently large number of individuals at the same time, and examples of this are given by Dr. Wallace in his work on "Darwinism," to which our readers are referred for further details on the point.

The Effects of Isolation. The importance of the isolation of a portion of a species in the process of organic evolution has been insisted upon by various writers, notably by Romanes. Isolation of those individuals who exhibited any special variation would undoubtedly preserve such a variation. Moreover, complete isolation involves the idea that new competitors as well as enemies are not a factor in the case, and, in the absence of these, intercrossing would be prevented. Isolation, to prevent the effects of intercrossing, is, of course, rigidly practised in artificial breeding by selection.

The point is, how far does the same factor operate in organic evolution in Nature? It happens in cases where any particular species reach oceanic islands and places where adaptation to new environments becomes a necessity. It is significant that such islands are very rich in distinct species. It is quite evident that some form of the isolation of new variations is a necessity for their persistence, otherwise they would be lost. But this isolation may be attained in other ways than geographically—for example, by physiological selection of individuals.

We still require more precise evidence in regard to the swamping effects of intercrossing where there is no isolation. All that is necessary here is to draw attention to this aspect of the evolution problem.

Darwin himself, in his "Origin of Species," admits that "isolation is of considerable importance in the production of new species," though he was, on the whole, "inclined to believe that largeness of area is of more importance."

There are other minor difficulties which have been advanced from time to time against the full acceptance of Darwinism, but they belong rather to the detailed study of the subject, and we must read the original writings of Darwin and Wallace to appreciate them. Indeed, those works should be read by every educated man. They are fascinating in themselves and epoch-making in their history.

The Evidence from Geology. Here, however, we must leave Darwinism for the present, and turn to a different aspect of organic evolution. From the present we turn to the past, from the living to the dead, from the story of the nations to the story of the rocks. In them also, if we read the signs aright, will be found precisely analogous evidence of the universal law of evolution in the world.

In the early part of this course we saw that, in order to gain a complete history of any species, it was necessary to study what is known of its distribution in the bygone ages. This aspect of biology is necessarily confined mainly to creatures which have or had a hard skeleton, which, though buried for many centuries, still is sufficiently preserved to indicate its structure. The study of the distribution of species from the point of view of time is termed *Palæontology*, and it is bound up with that of geology. In order, therefore, to fully appreciate this part of our task we must read also the section of this work dealing with geology.

The Story Told by Fossils. From what we have already learnt of the theory of organic evolution, we have come to the conclusion that animals have gradually become complex from more simple forms. We know that this complexity has not been an uninterrupted progress, but that, from various causes, animals have been extinguished from time to time, sometimes on a very large scale, and that they have also undergone degeneration in certain directions as well as progress.

The study of geology introduces us to extinct animals. Indeed, in some groups we find that there are more extinct species than existent ones. It is therefore to be expected that evidence of organic evolution will be abundant amongst fossil forms as well as in the species now inhabiting the globe. We may reasonably hope to find forms which, as it were, fill in the gaps between existing species and their remote ancestors, forms which may be regarded as connecting links between various species still existing, evidences of the actual variations which have been the stepping-stones to the modern forms of life.

To a certain extent the study of Palæontology satisfies these expectations. But many gaps still remain unfilled, and the connecting links in many cases are still to be found. Some urge this incompleteness as an argument against organic evolution, but, considering the comparatively short time which has elapsed since search has been systematically made in this direction, and the enormous area in the world open to investigation, the real wonder is the enormous mass of material which has already been collected.

Why the Record is Imperfect. A moment's thought will show us that a number of favourable conditions are necessary in order that the species of any given age may be adequately preserved. "In the first place, the animals to be preserved must not die a natural death by disease, or old age, or by being the prey of other animals, but must be destroyed by some accident which shall lead to their being embedded in the soil.

"They must be either carried away by floods, sink into bogs or quicksands, or be enveloped in the mud or ashes of a volcanic eruption; and when thus embedded they must remain undisturbed amid all the future changes of the earth's surface. But the chances against this are enormous, because denudation is always going on, and the rocks we now find at the earth's surface are only small fragments of those which were originally laid down. . . . In view of such destruction we are forced to conclude that our palæontological collections, rich though they may appear, are really but small and random samples, giving no adequate idea of the mighty series of organisms which have lived upon the earth.

"All that we have a right to expect is that, as we multiply the fossil forms in any group, the gaps that at first existed in that group shall become less wide and less numerous; and also that, in some cases, a tolerably direct series shall be found, by which the more specialised forms of the present day shall be connected with more generalised ancestral types. . . . Now, evidence of evolution of these varied kinds is what we do find, and almost every fresh discovery adds to their number and cogency." (Wallace.)

It would be quite beyond the scope and object of this course to enter into a minute description of the fossil forms of life; all we desire to do is to ascertain their bearing on the problem of organic evolution, and the kind of evidence they afford.

Continued

Group 20

MATERIALS & STRUCTURES

7

Continued from page 818

OILS. PAINTS. VARNISHES

Oils and Fats. Paints. Varnishes. Spirits. Distemper. Size. Wax. Resin. Turpentine. Pitch. Creosote. Paraffin. Benzine. Etc.

By Professor HENRY ADAMS

Oils and Fats. The term oil is a generic expression embracing the hard, solid, odourless waxes, tallows, and fats, the viscid fluid oils, the odorous essential oils, and the solid, fluid, and volatile hydrocarbons obtained in Nature or by destructive distillation.

The subject may be divided into three well-defined groups—the fixed oils and fats, the mineral oils, and the essential or volatile oils.

Fixed or Fatty Oils. *The fixed or fatty oils*, although varying considerably in external appearance, really form a distinct and homogeneous group of subtances having great similarity of chemical composition. As found in commerce, oils possess a faint, characteristic taste, a slight odour, and some colour, generally brownish-yellow. These characteristics, however, are due to certain impurities. In a really pure condition most oils have scarcely any characteristic taste, odour, colour, or physiological influence.

The ordinary method of separating vegetable oils and fats from nuts, seeds, etc., of which they form constituent parts, is by pressure, with or without the assistance of heat. They are also obtained by the agency of solvents, principally by the use of bisulphide of carbon and the light petroleum spirit, benzine, these being methods of production of comparatively recent introduction. Fixed oils are used very extensively in the manufacture of soaps and perfumery. Other purposes for which they are largely used are burning, lubricants, paints, varnishes, in the manufacture of linoleum, etc.

Linseed Oil. *Linseed oil* is a dark yellow to amber-coloured oil obtained by pressing the seeds of the flax plant. *Raw linseed oil* is produced by steaming the crushed linseed before removing the oil. *Boiled linseed oil*, which is darker and dries more quickly than raw oil, is produced by boiling the raw oil with litharge or a similar substance. It is commonly called simply *boiled oil*. Linseed oil is largely used in paints and varnishes, and also in the manufacture of linoleum, etc., The refuse after the oil is pressed out is in the form of slabs called *oilcake*, used for fattening cattle.

Olive Oil. *Olive oil* is a greenish-yellow fluid obtained by pressure from the fruit or pulp of the common olive tree, and may be divided into three kinds : (1) *Virgin oil*, which is the product of the first pressing without the application of heat, etc. ; (2) ordinary olive oil, or *sweet oil* which is obtained from the second pressing after subjecting the pulp to boiling water; and (3) *Pyrene oil*, which is a greatly inferior oil produced by a third pressing. Olive oil is extensively used in liniments, ointments, etc., in medical work, as a salad-dressing, and in cooking, while the poorer kinds are used for lubrication, illumination and soap-making.

Castor Oil. *Castor oil* is obtained from the seeds of the castor oil plant (*Ricinus communis*) by first passing them between rollers, and then, after placing in hempen bags, subjecting to pressure in a powerful press, which squeezes out the oil. This oil is afterwards raised to boiling point in order to separate the impurities. When purified it is used as an opening medicine. In its raw state it is sometimes used as a lubricant.

Cotton-seed Oil. *Cotton-seed oil* is the name given to the oil expressed from the seeds of the various cotton plants. The seeds are first separated from the fibre, and then crushed, the oil obtained closely resembling olive oil, as a substitute for which it is often used. Cotton cake, which is the substance left after the oil has been produced, is extensively used as a manure, and also as a food for cattle.

Palm Oil. *Palm oil* is a fatty oil obtained from various palm trees, chiefly from the fruit of the oil palm, of the West of Africa, by the tribes of which it is used for butter. It is employed for lubricating machinery, and also in the manufacture of candles, soap, etc.

Rape Oil. *Rape oil*, also called *colza oil* and *rape seed oil*, is a thick, yellowish oil obtained from the seed of the rape plant. It is chiefly used for lubrication and in the manufacture of indiarubber, and, to a limited extent, for illumination.

Cocoa-nut Oil. *Cocoa-nut oil* is a white, solid substance obtained from the cocoa-nut palm, and when subjected to pressure, is divided into two parts, one liquid and the other solid, the latter being known as cocoa stearin and used largely in the manufacture of candles. Cocoa-nut oil is also used in making marine soap, which lathers in sea water.

Tallow. *Tallow* is an animal fat derived mainly from sheep and oxen, and consists chiefly of stearin, palmitin, and olein. The tallow known to commerce is nearly always of a yellow colour, but animal tallow, when pure, is white. Commercial tallow is divided into several kinds, the best of which are used for candle-making, while the inferior qualities are used in the manufacture of soap, for dressing leather, and similar purposes. The purest is known as Russian tallow.

Margarine. *Margarine* is a substance extracted from hog's lard, and also from the fatty matter of various vegetable oils, the better qualities of margarine being obtained from olive oil, and consisting of stearin and palmitin. It is used for a substitute for, or an adulterant of, butter. *Pure butter* is produced by the churning of cow's milk.

Lard Oil. *Lard oil* is a colourless oil obtained from hogs' lard. It is used for lubrication and burning, for adulterating sperm and other oils, and in some places, especially the United States, for the manufacture of soap.

Sperm Oil. *Sperm oil*, which is an abbreviation of spermaceti oil, is, as its name implies, obtained from the spermaceti or sperm whale. It is used as train-oil, but not so extensively as the oil obtained from the common whale, which is known as *whale oil*. Sperm oil is also used as a lubricant.

Mineral Oils. *Mineral oils* are mixtures of hydrocarbons which are obtained directly from mineral sources, thus differing from the essential and fatty oils which are of vegetable and animal origin. *Petroleum* is the real mineral oil, and it is from this that the other oils are derived as described further on.

Essential Oils. *The essential or volatile oils* constitute a very extensive class, which possess, in a concentrated form, the odour characteristic of the plants or vegetable substances whence they are obtained. They are for the most part insoluble in water, or soluble only sparingly and with difficulty; but in alcohol, ether, fatty oils, and mineral oils, they dissolve freely. In many important respects they differ from the fatty oils; they are not oleaginous to the touch, and make no permanent grease spot, they have an aromatic smell and a hot, burning taste, and in chemical constitution they present no relationship to the fats and oils.

Essential oils have a wide range of uses, of which the principal is in perfumery. The value of flavouring herbs, condiments and spices is due in large measure to these oils which they contain, and further the commercial value of tea, coffee, wine, and other beverages is largely dependent on the delicate aroma which they owe to minute quantities of such oils. For the flavouring of liqueurs, aerated beverages and other drinks essential oils are used, and their employment is not less important in the manufacture of confectionery and in the preparation of many dietetic articles. In the arts the cheaper oils, such as oil of turpentine, are used in the manufacture of varnishes, and oils of turpentine, lavender, and spike are used as vehicles for painting, more particularly for the painting of pottery and glass.

An *emulsion* is a mixture of liquids where one is suspended in the other in the form of globules, both liquids being insoluble in each other, as, for instance, oil and water. It may also be a mixture in which a liquid contains solid particles in suspension—as, for example, camphor emulsion.

Wax. *Wax* is a solid, fatty substance of animal and vegetable origin, allied both in sources and constitution to the fixed oils and fats, from which it differs principally in its greater hardness and higher melting-point. Of wax from animal sources there are in commerce beeswax, which is by far the finest, Chinese insect wax, and spermaceti. The more important vegetable waxes are Japanese wax, myrtle-berry wax, carnauba wax, and palm wax.

Beeswax. *Beeswax* is secreted by all honey bees, and by them formed into the cell walls and other parts of their comb. It is separated by draining the honey, melting the drained comb in boiling water, and collecting the wax which solidifies on the top as the water cools. In this state it is formed into cakes of raw or yellow wax, good examples of which are of a light yellow colour, translucent, with a faint odour of honey.

The uses of beeswax are multifarious, but it is most largely consumed in making candles for the religious services of the Roman Catholic and Orthodox Greek Christians, and for wax figures and models.

Chinese Insect Wax. This wax is a secretion deposited by an insect on the twigs of a species of ash. The wax is, in its origin, etc., closely related to the lac produced by the allied species of *coccus*. When separated from the twigs, which it encrusts, and purified, it is a hard, translucent, white, crystalline body, similar to spermaceti, and in composition consists of *cerin*, one of the constituents of beeswax. It is little known in Europe, but forms an important trade in China and Japan, where it is largely used for candle-making and for medicinal purposes.

Japanese Wax. *Japanese wax* is a hard, wax-like fat, obtained from the small stone fruits of several species of *rhus* cultivated in Japan. It is not a true wax, but consists principally of the glycerine palmitin with small proportions of stearin and disseminated crystals of free palmitic acid. It is largely mixed with, and used as a substitute for, beeswax, except for uses where its rancidity renders it objectionable.

Myrtle-berry Wax. This is obtained from the fruit of several species of *myrica*, in the United States, New Granada, Venezuela, the Cape of Good Hope, etc. It is a hard, greenish substance, with a pleasant, balsamic odour, and consists principally of free palmitic acid with a little stearic acid and myristic acid. It is consumed principally in the United States in combination with beeswax for candles.

Carnauba Wax. Carnauba wax is an exudation on the surface of the growing leaves of the carnauba palm of tropical South America. The wax is obtained by cutting off and drying the young leaves, from which it is then shaken as fine dust, and caked by melting either over an open fire or in boiling water. It is a substance of considerable commercial importance in Brazil, whence large quantities are sent to Europe for use in the candle trade and otherwise, as a substitute for beeswax.

Palm-tree Wax. *Palm-tree wax* is an exudation formed on the stems of certain South American palms. As scraped from the trees and compacted by melting, it is a mixture of resin and wax. The pure wax, which is used for candles, may be separated by digesting with boiling spirit. This wax is little seen in European commerce

Spermaceti. *Spermaceti* is a solid, waxy body found in special cavities in the head of the sperm whale, where it is held in solution by sperm oil while the creature is alive. Spermaceti candles of definite size are employed as a standard for illuminants on account of the uniform, steady light they afford. The substance is further used in the dressing of fabrics, and in medicine and surgery.

Resin. *Resin* is a secretion formed in special resin channels or passages of plants, from many of which, such as coniferous trees, it exudes in soft tears, hardening into solid masses in the air. It is also obtained by making incisions in the bark or wood of the secreting plant. Certain resins are obtained in a fossilised condition, *amber* being the most notable instance of this class, and *African copal* and the *kauri gum* of New Zealand are also procured in a semi-fossil condition. The resins which are obtained as natural exudations are in general compound bodies containing more than one simple resin and varying proportions of essential oil. These compounds, when soft, are known as *oleo-resins*, and when imperfectly fluid, they are called *balsams*. Other resinous products are, in their natural condition, mixed with gum or mucilaginous substances, and known as gum-resins. A typical resin is a transparent or translucent mass, with a vitreous fracture and a faintly yellow or brown colour, inodorous, or having only a slight turpentine odour and taste. A series of gradations among resins may be traced from the hard, glassy, transparent copals through soft elemis and oleo-resins, semi-fluid balsams, and fluid wood oils, to the most limpid essential oils. The hard, transparent resins are used principally for varnishes and cement, while the softer, odoriferous oleo-resins and gum-resins, containing essntial oils, are more largely used for pharmaceutical purposes and incense.

Amber. *Amber* is a fossilised resin, of a pale yellow to reddish colour, the product of extinct varieties of pine trees which formerly grew where the Baltic Sea is situated, and by the waves of which the amber is now cast upon the surrounding shores, more especially on the Prussian coast. It is used chiefly for making beads, brooches, and the mouthpieces of pipes, and when heated with nut oil and thinned with turpentine, forms amber varnish.

Copal. *Copal* is a hard, lustrous, amber-like resin, which, when dissolved in turpentine or alcohol, forms one of the most valuable varnishes. There are many varieties, as Madagascar copal, Sierra Leone copal, South American copal, etc., but by far the most important—from a commercial point of view—is Zanzibar, or East African copal. It is found in two distinct conditions: the first, raw or recent, called *chakaze*, corrupted to "jackass copal;" the second, the true, or ripe copal. The raw copal is obtained direct from the trees or at the roots, and is not used in European commerce. The true, or fossil, copal is found embedded in the earth to a depth of three or four feet in places where not a tree is to be seen.

Canada Balsam. *Canada balsam* is a colourless resin, secreted in the form of a liquid under the bark of the balsam fir tree of North America, from which it is obtained by puncturing the bark. It thickens with age, and is used in making varnishes, but as it remains transparent permanently, it is chiefly used for mounting small objects for use under the microscope.

Turpentine. *Turpentine* consists of the oleo-resins which exude from certain trees, especially from some conifers, and from the terebinth tree (*Pistacia Terebinthus*). It was to the product of the latter, now known as *Chian turpentine*, that the term was first applied. Chian turpentine is a tenacious, semi-fluid, transparent body, yellow to dull brown in colour, with an agreeable, resinous odour and little taste, and on exposure to the air it becomes dry, hard, and brittle. In their general characters, turpentines are soft solids or semi-fluid bodies, consisting of a mixture of one or more resins with essential oils.

Oil or spirit of turpentine, pine oil, or turps, as a commercial product, is obtained from all or any of these oleo-resins, but on a large scale only from crude or common turpentine. The essential oil is rectified by distillation with water and alkaline carbonates, and the water which the oil carries over with it is removed by a further distillation over calcium chloride. Oil of turpentine is a colourless liquid of oily consistency, with a strong odour and hot, disagreeable taste. On exposure to the air it dries to a solid resin, and when oxidised in the presence of water, gives off peroxide of hydrogen, which is utilised in the preparation of the disinfectant called "Sanitas." Oil of turpentine is largely used in the preparation of varnishes, and as a medium by painters for their "flat" colours.

Rosin, resin, or colophony, is the residue left behind after the oil of turpentine has been distilled off from crude turpentine. It varies in colour from white to dark brown, according to the purity, the age of the tree, and the heat used in the preparation. It is used as a flux for solder, for rubbing on violin-bows, for combining with tallow in candle-making, also in inferior varnishes and sealing wax, as well as in the manufacture of the common yellow soap.

Alcohol. *Alcohol* is a volatile organic body, constantly formed during the fermentation of vegetable juices containing sugar in solution. It is extracted from spirituous liquors of different kinds by successive distillations. The alcohol, being more volatile than water, gradually accumulates in the first portion of each distillate. After a few operations, the spirit obtained is as strong as it can be made by this process, and further repetition does not separate more water from it. In commerce, the strongest spirit is known as spirit of wine, and contains about 90 per cent. of alcohol. The remaining 10 per cent. of water must be removed by some chemical agent that will combine with water and retain it at the boiling point of the spirit, and be without any specific action on the alcohol. Lime is generally used for making the absolute alcohol of commerce. For this purpose the caustic lime is broken into pieces about the size of a walnut and placed in a retort, spirits of wine is now poured into the vessel, just sufficient to cover the lime, and the whole is left for a night, during which time the lime gradually slakes from the absorption of water, and the anhydrous alcohol is left to distil off.

Absolute or *pure alcohol* is a colourless liquid, of a pleasant smell and acid, burning taste, with a specific gravity of 0·794. It mixes with water in all proportions, is a solvent for organic principles, bases, resins, oils, etc., and as such has an extensive use in the arts and in medicine. Different grades of alcohol are sometimes designated in trade according to the source from which they are derived, as *grain alcohol*, prepared from maize or other grain; *root alcohol*, from potatoes and beets, and *moss alcohol*, which is made in large quantities in Russia, Norway, and Sweden. *Proof spirit* contains 49·3 per cent. by weight, or 57·1 per cent. by volume of pure alcohol; *overproof* and *underproof* are designations of a stronger and weaker solution respectively. Distilled liquors or ardent spirits, such as whisky, brandy, and gin, contain 40 to 50 per cent. of absolute alcohol, wines from 7 to 20, porter and ale from 5 to 7, and beer from 2 to 10 per cent.

Methylated Spirit is a mixture of ordinary spirit of wine or alcohol, with one-ninth of its volume of wood-naphtha (*methylic alcohol*). The naphtha communicates a disagreeable flavour which renders the spirit unfit for drinking. It is of much use in the arts as a solvent, for preserving specimens, in the manufacture of varnishes, for burning in spirit lamps, etc.

Lac. *Seed-lac* is obtained from *stick lac*, which is the name given to the resin-covered twigs of various trees of Southern Asia, by removing the resinous substance from the twigs and grinding to a fine powder in water, which dissolves the greater part of the colouring matter, leaving the granular residue which, after drying, is the seed-lac.

Shellac is seed-lac melted, strained through thick canvas, and formed into thin layers or plates. Shellac, which varies in colour from a dark amber to an almost pure black appearance, may be bleached by dissolving in a boiling lye of caustic potash and passing chlorine through the solution till all the resin is precipitated. Lac is a principal ingredient in sealing wax, and forms the basis of some of the most valuable varnishes, besides being useful in various cements. Though lac is to be found everywhere, British imports are almost entirely drawn from Calcutta, which derives its supply chiefly from the hills of Chutiá Nágpur, but also to a less degree from Assam and Mirzápur in the North-Western Provinces.

French Polish. *French polish* is a liquid used for polishing wood, prepared by dissolving shellac and a little colouring matter in methylated spirits of wine. It is applied with a sponge or rag, and the surface is then rubbed very thoroughly with a soft pad, sticking being prevented by an occasional touch of linseed oil on another rag. The operation is usually repeated two or three times, to prevent the grain of the wood from rising thorugh the polish. *Glazing* is a cheap imitation of French polishing put on as a varnish.

Varnish. *Varnish* is a fluid preparation which, when spread out in thin layers, dries either by evaporation or by chemical action into a hard, transparent and glossy film. The materials which form almost exclusively the permanent body of varnishes are the drying oils and resinous substances, the chief of which are the copals, lac, dammar, elemi, amber, mastic, sandarac and resin. For certain forms of varnish the drying oils themselves act as the solvent for the resin, but in other cases volatile solvents are employed, those chiefly used are methylated spirit, wood spirit, ether, benzine, turpentine and other essential oils.

According to the solvent employed, the ordinary kinds of varnish are divided into three classes—(1) spirit varnishes, (2) turpentine varnishes, (3) oil varnishes.

Spirit Varnishes. *Spirit varnishes* dry with great rapidity owing to the volatilisation of the solvent spirit, leaving a coating of pure resin of great hardness and brilliance, but the film is deficient in tenacity, cracking and scaling readily on exposure. The resin lac, either as grain, shell or bleached lac, is the basis of most spirit varnishes, but sandarac is also used largely, and to these are added, in varying proportions, the softer resins elemi, Venice turpentine, mastic, etc., which give elasticity and tenacity to the varnish. The solvent is almost exclusively methylated spirit. Spirit varnishes are used principally for cabinet work and turnery, stationery, gilding and metal-work.

Turpentine Varnishes. Turpentine is the solvent principally used for making dammar varnish, the solution being effected by powdering the resin and boiling it with a proportion of spirit of turpentine, after which more turpentine is added in the cold state to bring the preparation to a proper consistency. Turpentine varnishes are also made in which the principal resinous bodies are sandarac and common resin, and, moreover, turpentine is largely employed to reduce the consistency and to improve the drying properties of copal varnish.

Oil or Fatty Varnishes. In these the basis or solvent consists principally of linseed oil, but the other drying oils—poppy and walnut—may also be used. It is in the form of boiled oil, or of oil prepared with driers, that these oils are used in varnish making. The resin principally used in oil varnishes is copal, and its varieties differ very much in hardness—that is, in the temperature at which they melt and distil.

Paints. *Paints* may be divided under several heads, according to the chief ingredient or base which is mixed with the vehicle or medium, or carrier—such as lead paints, oxide paints, zinc and baryta paints, graphite paints, etc. Generally speaking, lead paints are used upon woodwork, oxide of iron and graphite paints upon ironwork, zinc and baryta paints upon surfaces exposed to the impure air of towns, where white or delicate tints require to be preserved from the sulphur impurities which turn lead paints black. Besides the base and vehicle, it is generally necessary to add a *drier* to oxidise the vehicle rapidly and cause it to dry quickly, and a *solvent* to dilute the vehicle so that it will flow readily from the brush, besides the *pigment* for giving the required colour.

Lead Paints. *White lead* is a mixture of hydrated oxide and carbonate of lead in proportions of approximately 25 per cent. of the former and 75 per cent. of the latter. The Dutch method of manufacture is a long process, but is briefly as follows: Metallic lead, in the form of discs called "buckles" or open cast grids, is laid on earthenware pans containing vinegar, which are afterwards piled into bins, covered over, and left for about three months. During this time the temperature rises and a complex chemical change takes place by which the buckles are converted into white carbonate. The white lead is ground to a fine powder and mixed with 10 per cent. of linseed oil, forming the paint known as white lead in oil.

Red lead, or minium, is a pigment made by exposing litharge or massicot to air at a very high temperature, under which conditions it absorbs more oxygen. When mixed with linseed oil and mastic it is used as a cement; but it is used chiefly as a pigment, for the reason that when mixed with either linseed oil or water it forms a good first coat owing to its great covering powers.

White Lead paint is not only poisonous, but it rapidly blackens in the presence of the sulphurous fumes which are present in the air of all towns. On the coast, where it is subject to the action of the sea air, it is liable to "chalk off," that is, rub off with the hand as if the wood had been chalked.

Zinc Paints. *Pure zinc oxide paint*, ground in pure, refined, boiled linseed oil, furnishes a permanent white with great covering power, without requiring the addition of driers, but it is necessary to ensure that it is *zinc oxide*, and not merely *Charlton white*. Being a pure white, it permits of mixing to delicate shades of colour which the yellowish tinge of white lead will not allow. It is non-poisonous, and not acted upon by sulphuretted hydrogen. The largest manufacturers of zinc white are the Vielle Montagne Company of Jenappe, Belgium, who turn out about 12,000 tons per annum.

Charlton white or *lithopone* is composed of zinc sulphide and barium sulphate. It is sometimes used as a substitute for white lead paint for inside use, as it has greater covering power and keeps its colour better, but it does not give so hard or permanent a surface.

Iron Oxide Paint. *Iron oxide paint* has, as the base, a magnetic oxide or sesquioxide of iron prepared from hæmatite ore. It has been used for many years as preferable to lead paints for painting ironwork, but is now giving way to graphite paints, which experience shows to be more lasting.

Graphite. *Graphite*, or *black lead*, is one of the forms in which carbon occurs in Nature, and it receives its name from its use in the manufacture of writing pencils. Besides pencils, it is used for burnishing iron to prevent rust, and also for placing between rubbing surfaces of machinery to prevent friction. The best quality of graphite used for pencil making is obtained chiefly from Siberia, while the coarser varieties, from Ceylon and elsewhere, are used for stove polish and lubrication.

Graphite paint is a mixture of graphite with pure linseed oil. It is the best preservative among the oil paints for surfaces of iron and steel.

Metallic Paints. There are several varieties of these for giving lustrous surfaces, such as bronze, gold, silver, etc. The most recent is "Lustrogen," an aluminium paint, which is said to retain its brilliancy indefinitely, and to have a covering capacity of 900 to 1,000 square feet to the gallon. It resists sewer gas, sea-air, sulphuretted hydrogen, damp, and heat, and is suitable for stable fittings and all ornamental ironwork.

Enamel paints consist almost entirely of zinc oxide mixed with a varnish and the necessary colouring materials. It is the zinc white which gives these paints their peculiar durability.

Fire-resisting paints contain soluble glass in their composition. For example, a good white paint is made with finely ground zinc white (*oxide of zinc*) mixed with a solution of soluble glass (*silicate of soda*), with a strength of 40 to 45 degrees of the Beaumé hydrometer, until it has attained the consistency of ordinary paint.

Cyanite is a colourless preparation put on as a paint, for preventing wood from flaming when exposed to fire.

Fire-resisting putty is made of soluble glass (*silicate of soda*) mixed with ground chalk, and hardens within six or eight hours. It may be coloured with sulphide of antimony, iron filings, or zinc filings, incorporated with chalk.

Polishers' putty, or putty powder, is powdered oxide of tin, used for polishing glass, granite, and other hard substances.

Water Paints. Certain washable paints or distempers are known by this name, such as *Duresco*, made by the Silicate Paint Co., of Charlton; *Olsina*, by Mander Brothers, of Wolverhampton; *Hall's Sanitary Washable Distemper*, by Sissons Brothers & Co., Ltd., of Hull; *Magnite Sanitary Water Paint*, by Clemons, Marshall & Carbert, of Leeds; and *Mayresco*, by Mayfield Brothers, of Sulcoates, Hull.

Luminous Paint. Balmain's luminous paint is made by heating a mixture of sulphur and powdered oyster-shells in a closed crucible, forming a polysulphide of calcium, which is then mixed with mastic varnish. It is used for clock dials, lanterns for powder magazines, etc., owing to its peculiar property of emitting light, in darkness, without a flame; also for keyhole escutcheons, match boxes, and other small articles requiring to be seen in the dark. It is generally painted over the under side of a sheet of glass to protect it from being rubbed off.

Size. *Size* is a substance of a gelatinous nature, like weak glue. The best is made from leather parings, parchments, etc., boiled in water and afterwards purified. For common purposes, it is made from potatoes, glue, or scraps of horns, hides, etc., and is used for preparing writing-paper, and also by painters for stopping the pores of the material to which it is applied to reduce its absorbent power. It may be rendered less liable to putrefaction by adding one-tenth of a pound of boracic acid to each gallon of liquid size, or a little carbolic acid will effect the same purpose. The smell may be rendered less objectionable by the addition of a little oil of cloves or essence of peppermint. *Sichel-glue* is a non-odorous size which dissolves in cold water.

Pumice-stone. *Pumice-stone*, or *pumice*, is a light, spongy mineral substance, formed by the solidification of the foam on molten lava due to the escape of gas or steam. It is generally of a whitish-grey colour, and consists of about 70 per cent. silica, 20 per cent. alumina, and 10 per cent. soda, potash, and iron oxide. It is extensively used as a smoothing material for ivory, horn, wood, paint, marble, and various metals. It is much used by house-painters for rubbing down the various coats of paint work. For some purposes it is ground to a powder and used in a similar manner to emery paper.

Artificial pumice is made from a mixture of calcined and crushed quartz and alumina, moulded up into the form of bricks.

Sal-ammoniac. *Sal-ammoniac* is the earliest known salt of ammonia, and is now called ammonium chloride. It was first manufactured in Egypt, and for many years Europe was supplied with it from that country. It occurs usually in the form of a hard, white cake, opaque, or only slightly translucent, with a cooling and rather disagreeable taste. The first attempt to manufacture sal-ammoniac in Europe was made in London about the beginning of the eighteenth century; but the first successful manufacture in this country was established in Edinburgh about the year 1760.

Spirits of Salt. *Spirits of salt*, known also as *hydrochloric acid, muriatic acid*, or *hydrogen chloride*, is a colourless, strongly acid solution, made by dissolving hydrogen chloride gas (*hydrochloric acid gas*) in water. It is extensively used in the arts. When *killed* by the insertion of scraps of zinc, it is used by tinmen as a soldering fluid in conjunction with sal-ammoniac.

Blue Stone. *Blue stone*, or *Roman vitriol*, or more correctly *sulphate of copper*, is prepared on a large scale direct from the cementation water from pyrites mines, by evaporation to the crystallising point. It is also prepared by the oxidation of sulphide of copper in a furnace at a comparatively low heat, and by the direct action of sulphuric acid on metallic copper, as well as by various other processes. Sulphate of copper is very largely used as a basis for the preparation of other copper compounds, in electro-metallurgy, calico printing, and in the American method of extracting silver from its ores. It is also used in the preparation of the copper pigments, Scheele's green, Schweinfurt green, and Paris green. A solution of sulphate of copper is considered to be the best curative for dry rot in timber, put on as a paint, if the fungus has not obtained too firm a hold.

Copperas. *Green vitriol, ferrous sulphate*, or *copperas*, is a salt of iron, of a bluish-green colour and an astringent, inky, and sweetish taste. Copperas is manufactured, with alum, by the oxidation of the iron-pyrites contained in aluminous schists, such as those of the coal-measures of Renfrew and Lanark. It may also be prepared by Spence's method of heating ground puddling-furnace slag, tap-cinder, or Cleveland ironstone with sulphuric acid. Copperas is used in dyeing and tanning, in the manufacture of ink, Prussian blue, and Nordhausen sulphuric acid or fuming oil of vitriol, in medicine as an astringent and tonic, and in analytical chemistry.

Ink. *Ink* is a thin fluid used for writing and drawing, and also a thicker substance used in printing, being distinguished under the titles of *writing ink* and *printing ink*.

Common black writing ink is mostly made by steeping a mixture of galls, copperas, and gum-arabic, while the colouring matter is gallotannate of iron, and sometimes a little logwood is added to improve the colour.

Printing ink is a mixture of boiled oil and the colouring pigment. When the ink is required to be fine, nut and other fine oil is used, sometimes mixed with a little resin; but for the coarser inks resin only is used. The pigment for black inks is generally lampblack, while, to improve the impression, soap is also added.

There are also many other varieties of ink, as: India, China or Indian ink, book ink, copying ink, marking ink, lithographic ink, etc.

Continued

Group 27

SHORTHAND

7

Continued from page [illegible]

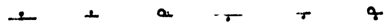
SHORTHAND

Seventh Instalment of the Special Course of Shorthand Taught by Messrs. Pitman & Sons on their Twentieth Century Plan

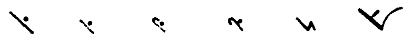
By SIR ISAAC PITMAN & SONS

TWO highly important abbreviating principles are introduced to the student's notice in this instalment, namely the expression of additional consonants either by halving or doubling the length of any consonant.

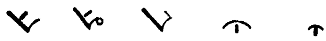
The Halving Principle. Light consonants are made half their usual length to indicate the addition of *t*; thus



ache, *ached*, *sect*, *Kay*, *Kate*, *skate*,

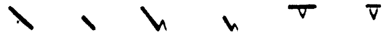


pay, *pate*, *plate*, *prate*, *pout*, *bowl*,

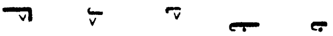


bolt, *bolts*, *bullet*, *mow*, *moat*.

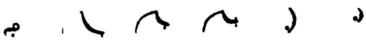
Heavy consonants are made half their usual length to indicate the addition of *d*; thus



ebb, *ebbed*, *bow*, *bowed*, *guy*, *guide*,

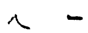


guided, *glide*, *Gride*, *grey*, *grade*,



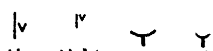
grades, *live*, *lived*, *livid*, *ease*, *cased*.

It will be noticed from the foregoing examples that a vowel coming before a half-length character is read first, the same as before a full-length consonant; as



oft, *act*.

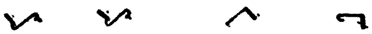
A vowel coming after a half-length consonant is read NEXT to the primary letter; thus



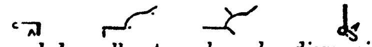
tie, *tight*, *no*, *note*.

When a consonant is hooked *finally*, it may be halved to express the addition of EITHER *t* OR *d*; thus *paint* or *pained*; *plant* or *planned*; *tint* or *tinned*; *tents* or *tends*; *vent* or *vend*; *mounts* or *mounds*; *rent* or *rend*; *puffed*, *paved*.

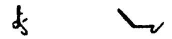
In words of *more than one syllable*, with certain exceptions, a letter may be halved to express the addition of EITHER *t* OR *d*; thus



between, *Bedwin*, *rabbit*, *rabid*, *credit*,



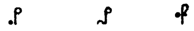
crowded, *collaret*, *coloured*, *disappoint*,



despond, *backward*,

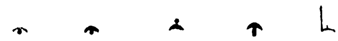
forward (*wd* contraction for *-ward*);

dockyard (*yd* contraction for *-yard*);

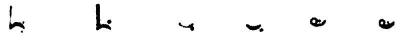


seated, *suited*, *stated*.

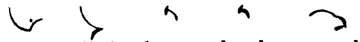
The four consonants in addition to being halved to express the addition of *t*, are also halved and thickened to represent the addition of *d*; thus



mate, *made*, *aimed*, *mode*, *tempt*,

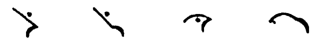


timid, *deemed*, *neat*, *need*, *sent*, *send*,



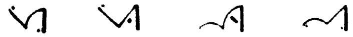
felt, *felled*, *heart*, *hard*, *moored*.

The forms *ld* and *rd* are, however, used only when these consonants immediately succeed each other, as



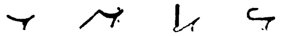
paled, *paired*, *mailed*, *marred*.

When a vowel comes between *l-d*, or *r-d*, these consonants must be written in full; thus



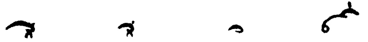
pallid, *parade*, *mellowed*, *married*.

Lt is written upward; as belt, except after *n*, *ng*, *w*, *kw*, when it is written downward, as

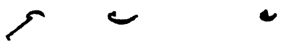


knelt, *ringlet*, *dwelt*, *quilt*.

The consonants *mp*, *ng*, cannot be halved to express the addition of either *t* or *d*, unless they are hooked, initially or finally; thus



impugn, *impugned*, *impend*, *slumbered*,



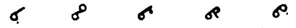
rampart, *anger*, *angered* or *anchored*.

The double consonants *lr*, *rr*, cannot be halved for the addition of *t* or *d* under any circumstances. The heavy half-length signs are allotted to *md*, *nd*, *ld*, and *rd*.

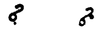
Exercise.

1 Pet, pit, Tate, taught, kit, aft, east, shot.
2 Wit, await, light, alight, yet, plot, crate.
3 Bed, aided, edged, jade, goad, egged, mead.
4 Old, erred, blade, bread, glade, broad, dread.
5 Pound, fined, accident, inward, brickyard.
6 Meat, mud, night, Ned, admit, doomed, fillet, failed.
7 Bailed, ballad; showered, charade; tarred, tirade.
8 Pelt, polite, kilt, melt, omelet, inlet, runlet.
9 Impound, dampened, lingered, hungered.

The upward *h* must be written in words that contain *h* halved, with or without final circle or hook, as

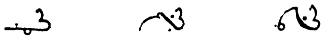


hat, hats, heat, hunt, hints,



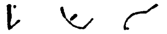
haft, heaved.

After the *-tion* hook, the stroke *st* may be written upward when it cannot be written downward; thus

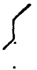
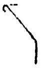
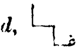


excursionist, liberationist, salvationist.

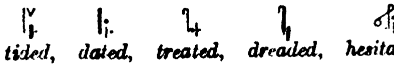
The half-length *r* [/] should never be written alone, nor with *s* only [ ] added. Write [not] *rate,* [not] *write,* [not] *writes.* It should generally be used finally for *rt,* and for *rd,* when it is not convenient to write ; thus



dart, fort, lard.

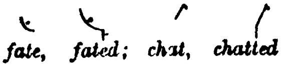
Two half-length strokes, or two strokes of unequal length, must not be joined together UNLESS THEY MAKE AN ANGLE; thus / *cht* must not be joined to / *cht* for *chit-chat;* nor *pr* to \ *pt* in *propped;* nor — *k* to – *kt* in *tactics,* nor ⌒ *m* to ◡ *nt* for *minute.* Detach the signs, or write the letters in full; thus or  *chit-chat,*  *propped,*  *tactics,* *minute.* In *ford,* *named,* etc., the junction, being evident, is allowed.

Half-sized *t* or *d* immediately following the consonants *t* or *d* is always disjoined; thus

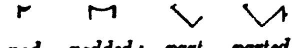


tided, dated, treated, dreaded, hesitated.

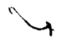
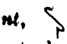
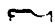
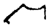
Verbs written with the half-length principle form their past tense thus



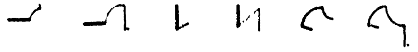
fate, fated; chat, chatted;



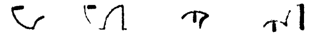
nod, nodded; part, parted.

Verbs written by a half-length letter ending with a hook form their past tense thus *print,*  *printed,* *plant,*  (to preserve the straightness of the stroke) *planted,* *stint,* *stinted,* *acquaint,* *acquainted,* *grant,*  *granted,* *rant,*  *ranted.*

When a word ends with *t* or *d* followed by a vowel, the letter must be written in full, and not indicated by the halving principle; thus

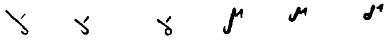


guilt, guilty; dirt, dirty; loft, lofty;

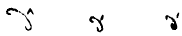


fault, faulty; mould, mouldy.

The circle *s*, as already explained, is always read *last* when it is written at the end of a word; thus



pun, punt, punts; join, joint, joints;

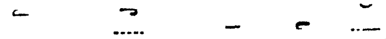


frown, front, fronts.

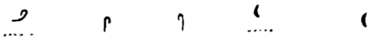
Exercise.

1 Hate, height, hit, hits, huffed, hounds.
2 Fashionist, elocutionist; evolutionist, revolutionist.
3 Wrote, writ, write, rout, port, tart, lured.
4 Pit-a-pat, bribed, tick tack, emanate, numbed.
5 Attitude, audited, vegetated, obtruded.
6 Fitted, potted, jotted, netted, rooted, pirated.
7 Branded, grounded, stunted, unacquainted.
8 Fort, forty; malt, malty; neat, natty; loved, love-day.
9 Tin, tint, tints; pine, pint, pints; shunt, shunts.

Grammalogues. The following additional grammalogues should be memorized:

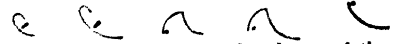


call-d(¹), *cannot*(¹), *could, great, not*(¹),

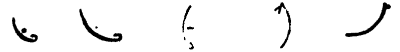


short(¹), *told, toward, that*(¹), *without.*

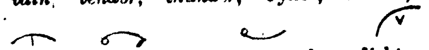
The Double-Length Principle. Curved consonants are made twice their usual length to indicate the addition of *tr, dr,* or *thr*; thus



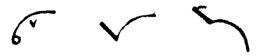
flow, floater, laugh, laughter, father,



vain, vendor, thunder, oyster, shatter,

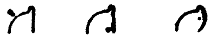


mother, smoother, centre or *sender, lighter,*



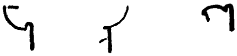
slighter, builder, border.

When *dr* or *thr* follow an initial *l*, they are expressed by and not by doubling the *l*; thus



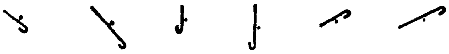
older, leader, leather.

After *f, sh, m* also, *dr* is expressed by and not by doubling; thus

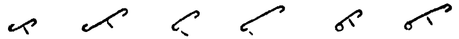


fodder, shudder, Modder.

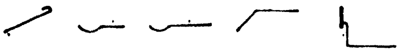
Straight consonants hooked finally, or which follow *another stroke*, are made twice their usual length to indicate the addition of *tr* or *dr*; thus



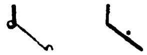
pain, painter, ten, tender, wren, render,



won, wonder, yon, yonder, Hun, hunter,

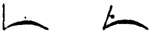


rafter, neck, nectar, rector, detractor,



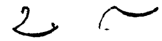
disputer, debater.

The character *mp* is doubled to express *mpr* or *mbr*; thus

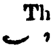


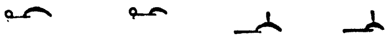
temper, chamber.

The character *ng* is doubled to express *ngkr* or *nggr*; thus

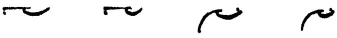


shrinker, longer.

The hooked consonants *mpr, mbr,*  *ngkr, nggr* are generally more convenient for verbs, because they can be readily halved for the past tense; thus

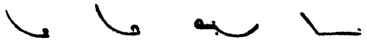


scamper, scampered, cumber, cumbered,



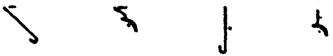
canker, cankered, linger, lingered.

In a few common words, it is allowable to double a letter to express the addition of the syllable *-ture*; thus

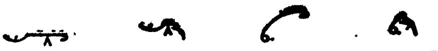


feature, future, signature, picture.

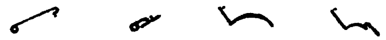
When the present tense of a verb is written with the double-length principle, the past tense is written with the half-length principle; thus



ponder, pondered, tender, tendered,

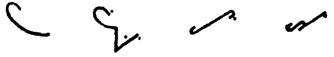


encounter, encountered, slander, slandered,

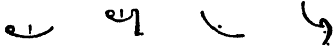


hinder, hindered, pamper, pampered.

When a word ends with a vowel preceded by *tr, dr*, or thr, these consonants must be *written* and not indicated by doubling; thus

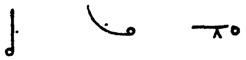


flatter, flattery, winter, wintry,



sunder, sundry, feather, feathery.

The circle *s* at the end of a double-length character is read *last*, as usual; thus



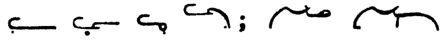
tenders, feathers, counters.

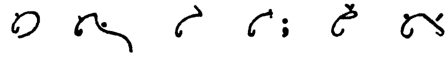
EXERCISE.

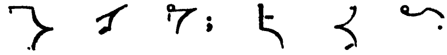
1 Enter, Easter, loiter, shutter, matter.
2 Founder, asunder, smatter, cylinder, Walter.
3 Palter, porter, folder, charter, chartered.
4 Letter, louder; latter, ladder; fetter, feeder.
5 Shouter, shedder; mutter, madder; fitter, federal.
6 Pointer, tinder, ranter, wander, wandered.
7 Elector, gunpowder, dissector, pretender.
8 Vamper, Humber, jumper, timber, belonger.
9 Slumber, slumbered; anger, angered.
10 Flounder, floundered; director, directory.

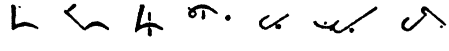
KEY TO EXERCISES IN LAST LESSON.

1 Quibble, quiet, quarter, quarrel, require, guano, languish.
2 Weal, wallow, wealth, Wells, wheel, whelm, meanwhile. wheeler.
3 Fuller, roller, skuller, poorer, admirer, borer, snorer.
4 Pump, jump, embellish, ambitions, whack, whip, whisper.

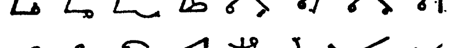
1 

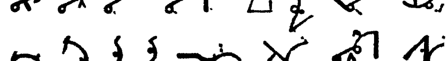
2 

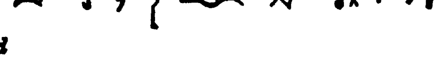
3 

4 

1 Hock, haggis, hod, hoary, haddock.
2 Hive, haggle, hairy, cohesion, unhinge.
3 Hilly, horror, hump, happily, handy.

1 

2 

3 

Continued

MORE ELEMENTS IN DETAIL

Bleaching Powder. Calcium. Metallic Elements, including Aluminium, Magnesium, Manganese, Iron, and Zinc

Continued from page 844

By Dr. C. W. SALEEBY

Bleaching Powder. Bleaching powder is another very important substance which contains calcium, though this is really not the most important element in its composition. It is prepared by the action of chlorine—its active ingredient—on calcium hydrate, or slaked lime. This last, prepared with great care and free from impurity, is spread out in thin layers over the floor of stone chambers, and then chlorine gas is passed over it. The compound that is formed is of somewhat uncertain composition; it may perhaps be described as a mixture, or rather a semi-compound, of chloride and oxychloride of lime, and its composition may be indicated by the formula $CaOClCl$. This formula is only approximate, and must not at all be taken as comparable with the other formulas we have seen, which are exact. At any rate, bleaching powder contains a superfluity of chlorine which it is always ready to dispose of, and to which it owes its properties.

Another very common salt of calcium is its fluoride, which has the formula CaF_2.* This occurs as a very common mineral, very often in association with the ores of lead, and usually known as *fluor-spar*, or *fluorite*.

It forms very nearly transparent crystals, most frequently cubical. It is hard but brittle, and occurs in a large number of different colours, of which the most common is violet. Sometimes it occurs in alternate bands of violet and colourless structure; this form is known as Derbyshire spa.

Salts of Calcium. The *sulphate of calcium* ($CaSO_4$) is an important salt, which occurs in nature in different forms. One of these, sometimes called *anhydrite*, contains no water, but commoner forms, such as gypsum, contain two molecules of water of crystallisation to each molecule of the sulphate. Other water-containing forms of sulphate of lime are selenite and alabaster. Selenite is practically equivalent to gypsum, and alabaster is almost identical. The latter has a pearly lustre, is never transparent, is quite soft—in this respect these forms contrast markedly with anhydrite—and thus it can be very readily carved or turned; but it must not be exposed to rain, as it is soluble in water, though only slightly. If these forms of sulphate of lime are heated, there is derived the cement-like substance called *plaster-of-Paris*. In practice this is always obtained from the commonest form, which is gypsum. When heated at a temperature considerably above the boiling point of water, it loses its water of crystallisation, and forms a plastic substance which can be moulded to any form, and which on mixture with water speedily sets into a hard, rigid mass, which consists of a union, if not a true chemical combination, between the water and the salt. It is certainly more than a mere mixture of the two. This we know because a good deal of heat is produced as the plaster sets, and the evolution of heat is an invariable sign of the satisfaction of chemical affinity.

The *sulphide of lime* (CaS) is luminous in the dark, and may, therefore, be used to amuse children, and so forth. At one time it was largely employed in medicine, but is probably of no particular value as a drug.

The *phosphate of lime*, a compound of lime and phosphoric acid, occurs in nature as a mineral called *apatite*. It is constantly found in the animal body, forming some 60 per cent. of the structure of the bones, and even a higher proportion of the teeth. Minute quantities of the fluoride of calcium are also found in teeth.

Barium. Barium is a very heavy metal, which closely resembles calcium in many of its chemical properties. It has recently obtained much fresh theoretical importance from the fact that it seems to have certain relations to radium. Its atomic weight is about 137. Its name is derived from the Greek word *barys*, heavy. Barium is never found in the elemental state in nature, but occurs in the form of two salts—the sulphate, which forms the mineral known as *barytes*, or *heavy spar*, and the carbonate. Like sodium and potassium, barium was first isolated by Sir Humphry Davy; its oxide closely corresponds to the oxide of calcium, and has a similar formula BaO. It is known as *baryta*. The characteristic colour produced by barium salts when they are heated to incandescence is green, and some of them, such as the chloride and nitrate, are often used in fireworks for this purpose. Barium also forms a dioxide (having the formula BaO_2), as indeed does calcium. The calcium salt is of no importance, but the barium salt is used as a means of preparing oxygen in large quantities. In the first place the salt is formed by heating the ordinary oxide to dull redness in air, from which it takes a certain amount of oxygen so as to form the dioxide. When this is heated still further it gives off the extra oxygen which it has taken up at a lower temperature. Instead of raising the temperature further, the same changes may be made to occur by altering the pressure, which comes to the same thing. Air is forced into tubes containing the oxide, the dioxide being formed whilst the nitrogen of the air escapes. Then when the pressure is lowered, the oxygen previously taken up is given off again, and can be collected.

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* If the reader is not sure that he knows what these formulas mean, he should turn back to the place where they are discussed.

Strontium. The last element dealt with in this group is *strontium*, which is of less importance than any of the others. Its atomic weight is about 87·5, and its chemical symbol Sr. It also was first discovered by Davy, being *prepared, as we have already seen, by electrolysis of the fused chloride. It is a yellowish, malleable metal,* which readily oxidises on exposure to the air, and also decomposes water in the fashion which should now be familiar. It is found in nature in the form of the sulphate and carbonate. As in the case of barium, its chloride and nitrate are soluble, and can be used, especially the latter, in fireworks. It produces a splendid crimson colour. The sulphate of strontium is peculiar in that it is less soluble in hot water than in cold.

Magnesium and zinc are the next two metals to be discussed, since they form a group. They are both metals heavier than water, but, unlike the preceding metals, not liable to act upon it, save slightly, if the water be boiled.

Magnesium. Magnesium is not found in the elemental form in nature, but is abundant in certain compounds. Of these the commonest are the carbonate, the double carbonate of calcium and magnesium, which is known as *dolomite*, the sulphate (which occurs, for instance, as the mineral Epsomite, reminding us of the medicinal use of the sulphate of magnesium, or Epsom salts), *carnallite*, which is a double chloride of magnesium and potassium, and in the form of various mixed silicates, such as *asbestos*, *tourmaline*, and *meerschaum* (literally sea-foam). Again it is Sir Humphry Davy who has the distinction of having first isolated magnesium. The metal is now prepared from its chloride, from which it is displaced by means of metallic sodium. It is extremely light, insoluble in water, but readily soluble in acids. Its atomic weight is 24, and its symbol Mg. The reader must not confuse magnesium (with the symbol Mg), and manganesium, or manganese, which has the symbol Mn. When magnesium is heated in air it burns with an exceedingly brilliant light, and forms the oxide of magnesium MgO. This is usually known as magnesia; and is a tasteless, insoluble, light, white powder of considerable use in medicine. It is not, however, usually prepared by the oxidation of magnesium, but by heating magnesium carbonate, which salt is decomposed, giving off carbonic acid in a manner exactly similar to the decomposition of calcium carbonate and the formation of quicklime.

The light produced by the oxidation of magnesium is not only extremely brilliant, but is especially rich in those rays of light which are most markedly powerful in their chemical action on a photographic plate. Hence it is largely used for photography.

Zinc. Zinc has the symbol Zn, and its atomic weight is 65. It occurs in nature only in combination in the forms of carbonate, usually known as *calamine*, and the sulphide, which is known as *blende* or "black-jack." Calamine is of no particular importance; sometimes it is powdered, carefully purified and tinted, for application to the face. It is from the blende that metallic zinc is prepared. The blende is roasted in air, yielding zinc oxide and the oxide of sulphur, which is volatile, and escapes. The oxide, which is a powder, is treated with charcoal, which takes the oxygen from it. The operation is conducted at a high temperature, at which the zinc is produced in gaseous form. It is never obtained pure by this process. Zinc does not tarnish readily in the air, and so may be used for coating sheets of iron, and thus protecting them from the atmosphere. Iron thus treated is known as galvanised iron. The zinc is not affected even if the air be moist. When zinc is strongly heated, it readily burns and forms an oxide (ZnO). This oxide is of some use in medicine, being incorporated with lard as zinc ointment, which is soothing, and very feebly antiseptic. The chloride of zinc, having the formula $ZnCl_2$, is obtained by evaporating a solution of zinc in hydrochloric acid; it is a very powerful antiseptic, and is the basis of Burnett's Disinfecting Fluid. Zinc forms some important alloys. With copper it forms brass, which is made by melting the copper and adding zinc to it; with tin it forms bronze, and with copper and nickel it becomes "German silver."

Boron. The next group of elements we have to consider consists of boron and aluminium, the latter of which is promising to become of great importance. Boron has the symbol B, and its atomic weight is about 11. It is not to be regarded as a metal. It was first isolated in 1808, the year following the discovery of sodium and potassium. It is not found in the elemental form in nature, but occurs chiefly as borax, already discussed under sodium. Borax has a very feeble antiseptic property, but this is decidedly more marked in boric acid, or boracic acid, which is derived by the union of water with the oxide of boron. This oxide has the formula B_2O_3. Boracic acid may be obtained by the action of a strong acid upon borax, but this method is not usually employed, since the acid occurs in nature in certain springs in Tuscany. From the water of these springs it may be prepared by evaporation. The uses of the acid as a mild antiseptic are familiar. Boron also occurs in large quantities as the mineral called boracite, which is a compound or combination of the borate of magnesium and the chloride of magnesium. It occurs in association with gypsum and with common salt in some parts of Germany. It is of no practical importance, and the same may be said of all the other compounds of boron.

Aluminium. The next metal with which we have to deal—aluminium—is exceedingly abundant, as we have already seen, and has lately become of very great commercial and practical importance. It is a white metal, specially characterised by its extreme lightness. Its specific gravity—that is to say, its weight compared to the weight of water represented as 1 [see PHYSICS]—is only 2·6. Besides this extreme lightness, which is often of much practical value, aluminium has other useful physical properties. It is ductile, and can be drawn into wire; it can also be readily cast, and can be rolled into sheets. It melts at the comparatively low temperature of 700° C. Aluminium tarnishes very slowly on exposure to air, but it forms alloys which are in this and some other respects more valuable than itself. Its alloy with copper, for instance, known as aluminium-bronze, is scarcely liable to tarnish at all. It is of a yellowish colour.

Though so abundant, being a constituent of most rocks, and the characteristic element of clay, aluminium, until very recent times, has been very expensive to obtain in a pure state. It has had to be extracted from clay by a series of very difficult operations. At the present time, however, aluminium is prepared by an electrical method which has enormously reduced its cost. The principle is that of electrolysis, consisting essentially in the passage of an electrical current through solutions containing the required product. The method in present use is now nearly 20 years old. The material employed for electrolytic production is a mixture of cryolite—the double fluoride of aluminium and sodium, with alumina—the oxide of aluminium.

The widest practical use of this metal at the present time is in the purification of iron and steel—a use which is due to the fact that the metal at high temperatures is able to decompose the oxides of nearly all other metals. It makes excellent cooking utensils, which do not break or chip or rust, are exceedingly light, and make no poisonous contribution to the food cooked in them. It is also largely coming into use in the place of copper as a conductor of electricity.

The compound alumina, which has already been mentioned, may be prepared as a white powder, which is characterised by its great affinity for colouring matters, and is thus largely used in dyeing and colour manufacture. The substance formed by the union of the colouring matter and the alumina is usually known as a *lake*. In its crystalline form alumina is second only to the diamond in the scale of hardness. [See PHYSICS.] Tinted by various impurities, it forms some of the most beautiful of precious stones, such as the ruby, the sapphire, and the amethyst.

A New Group. Our next group consists of one exceedingly important element, *iron*, and four of less importance, *chromium*, *manganese*, *cobalt*, and *nickel*. The sources of these metals are as follows. Chromium occurs mainly as chrome-iron ore, which is a double oxide of iron and chromium; manganese occurs in the form of its oxide, which has the formula MnO_2, nickel occurs in New Caledonia in the form of a silicate of nickel and magnesium, and both nickel and cobalt are found in nature in combination with arsenic.

These metals can be obtained in the pure metallic state by means of carbon, which turns them out of their oxides. We may first of all dispose of the four unimportant members of this group before going on to deal with iron, which demands lengthy consideration.

Chromium. Enough has already been said about the source and preparation of this metal; it is extremely hard, and of a grey-green colour. It combines with oxygen in various proportions, the most important compound of the two elements being chromic oxide, which has the formula Cr_2O_3. This is sold as a pigment under the name of emerald green, an accurate name, since the colour of the emerald is due to small quantities of chromium. There is also a double sulphate of chromium and potassium, which is known as chrome alum. The name is a bad one, since it contains no aluminium. The salt forms purple crystals, which are much employed in dyeing, calico printing, etc.

Manganese. Manganese, which must never be confused with magnesium, occurs in nature in several combinations besides the black oxide (MnO_2) already mentioned. Prepared as stated above, it is a very hard, brittle, whitish metal, which cannot be preserved in air, since it rapidly decomposes the water contained in air, becoming itself oxidised and giving off hydrogen.

Naturally enough, metallic manganese has no commercial uses, but its oxides are used in glass-making; and its alloys with iron, with which it frequently occurs in nature, are very valuable, as such iron yields very superior steel.

A very useful compound of manganese is the salt known as permanganate of potassium, which has the formula $KMnO_4$. It occurs in the form of small purple crystals. When these are dissolved they form a deeply coloured solution, with a very unpleasant taste, which is familiar to everyone under the name of Condy's Fluid. This compound contains an excess of oxygen, which, in the presence of water, it is very ready to give up to organic bodies. In consequence of the decomposition which then occurs, the solution loses its purple colour and becomes a dirty brown, due to the formation of the black oxide of manganese. This change in colour has the advantage that it enables one to see whether or not solutions of the salt have undergone decomposition. The solutions of this salt have been largely praised as antiseptics, and are still very generally believed in, but its virtues have been very much exaggerated. It should be looked upon rather as a deodoriser than as a true antiseptic. It has only very slight action against microbes, but it helps to complete the oxidation of the products of their action, and thus removes foul smells. Unfortunately it readily stains linen, cotton, and the like, but the stain may be removed by applying sulphurous acid and then immediately washing out the fabric in water. The oxidising properties of this salt have been found to render it very useful as an antidote in morphia poisoning. It oxidises any morphia that may remain in the stomach, whether taken as such or in the form of opium, and thus prevents it from acting.

Cobalt. This is a reddish-white metal, found, as stated, in combination with arsenic, and also as *cobalt glance*, which is a compound of cobalt, arsenic and soda. Compounds of cobalt, having a blue colour, are used as pigments, and also for giving a blue colour to glass and porcelain.

Nickel. Nickel is a metal of somewhat more importance than the others, chiefly in virtue of its use in strengthening steel. Nickel steel—that is to say, steel containing a small percentage of nickel—is so much harder than ordinary steel that it is said to offer about 20 per cent. better protection as armour-plate for ships than the best ordinary steel. Nickel is also used in the form of an alloy with copper for the manufacture of coins. The subject of nickel-plating is treated elsewhere. The metal closely resembles the others of this group. It is of a silvery white colour, very hard, though malleable, and melts at a very high temperature.

Iron. Iron is, of course, by far the most important and useful of all the metals, having an extraordinary variety of uses, and being important in manufacture, in the arts, and in medicine. Very small quantities of the metal are found in the pure state on the earth, and these only in rocks of volcanic origin. Iron, however, appears to occur extensively in its uncombined form in the heavens, and uncombined or metallic iron is found in quite considerable quantities in meteorites. [See ASTRONOMY.] The most valuable ores of iron are various oxides and the carbonate, these being the compounds of commercial importance. The magnetic oxide of iron, sometimes called *magnetite*, has the formula Fe_3O_4. Another oxide (Fe_2O_3) is known as *hæmatite*, and this occurs in several forms. The carbonate, no less important, occurs in what is called *spathic iron ore*, clay ironstone, or clay band, in which it is mixed with clay; and as *black band*, in which it is mixed with coal. Large quantities of these ores occur in this country. Other compounds also have a wide distribution. Iron pyrites, for instance, which has the formula FeS_2, is used less as a source of iron than as a source of sulphur. Various silicates of iron occur in many rocks and minerals.

The Extraction of Iron. In order to extract iron from its ores, the first thing to do is to perform the process of calcination, which consists of roasting the ore so as to break it up, to expel water and any gases it may contain, and also to burn off the sulphur which may be present. The ores are then ready for treatment in the blast furnace, where they are heated with coal and lime, the first being simply a convenient form of carbon used in order to remove the oxygen from the ore, and the lime being used as a flux, which forms with the sand in the ore a fusible glass called slag. This floats on the molten iron, and has to be removed at intervals.

The blast-furnace is a hollow tower, which may be as much as 100 ft. high, and which contracts towards its lower part, having at its very bottom the crucible where the actual operation occurs. Above the crucible are tubes through which there passes an incessant blast of hot air; this blast makes the combustion much more rapid, and therefore produces a much higher temperature. The exact sequence and nature of the chemical changes in the blast-furnace are not precisely known, but what happens is essentially this. The coal is oxidised to form carbonic oxide (CO), and this, which requires more oxygen, takes it from the oxide of iron; there is thus formed carbonic acid (CO_2), which escapes from the mouth of the furnace. Meanwhile the molten iron sinks in the furnace, while fresh layers of coal, lime, and ore have to be added from above. The resultant product is by no means a pure iron.

In the first place it contains a certain percentage of carbon derived from the coal, and in the second place a good deal of silicon derived from the earth and sand with which the ore is mixed up. This substance is known as *cast iron*, or sometimes as *pig-iron*; the bars which are formed by running off the molten iron from the crucibles being known as pigs. This iron contains, besides carbon and silicon, a certain amount of sulphur, phosphorus and manganese, though none of these are nearly so abundant as the carbon. There are three kinds of pig-iron, the differences between them depending upon the state of the carbon in them. If the iron cools very rapidly into the moulds into which it is run, the carbon remains combined with the iron, which is then white, and is called *white pig*; but if the cooling occurs slowly the carbon separates out in the form of black crystals of graphite [see CARBON, page 1046], and the iron is then called *grey pig*; whilst intermediate between grey pig and white pig is *mottled pig*.

Wrought Iron. Now, this kind of iron is very brittle. It cannot be forged or welded; the only use to which it can be applied is castings. When the pigs are remelted in small furnaces they may be employed for this purpose, which is facilitated by the fact that cast iron expands slightly as it solidifies. Now, what we want for purposes of forging and welding is a substance that shall have the strength of cast iron without its brittleness, and that substance, of course, is *wrought iron*. The difference between cast iron and wrought iron depends upon the fact that in the latter the impurities have been burnt out. This is done by melting the iron and exposing it in the molten state to blasts of hot air, which remove most of the carbon and silicon in the form of their oxides. This is the process known as *puddling*, the name being derived from the necessity of stirring the mass to a pasty consistence. The lumps of iron which are subjected to the puddling process are called *blooms*. Wrought iron is the purest form of iron that is found in commerce. It can be forged and welded, and even drawn into wire. It has a specific gravity of 7·6—somewhat greater than that of cast iron, which is less than 7·5—and has a rather higher melting point than cast iron, which melts at about 1,500° C. Before it melts, wrought iron becomes pasty, and can thus be welded at white heat. It contains usually less than one-half per cent. of carbon as compared with the 3 to 5 per cent. which occurs in cast iron.

The Bessemer Process. Wrought iron may be manufactured in a more satisfactory way than by puddling, and this is known as the Bessemer process, in which a current of air is blown through fused pig-iron in a pear-shaped vessel, itself made of iron and lined with firebricks. This leads us on to the important subject of steel. Steel contains less carbon than cast iron, but rather more than wrought iron, the percentage of carbon being from 1 to 1·5 ; it melts at 1,800° C., and has a specific gravity of 7·6 to 8. It used only to be made by the *cementation process*, which consisted in placing bars of wrought iron in boxes, surrounding them with powdered charcoal, and then heating them for days at a time. Nowadays the manufacture of steel is accomplished by adding another stage to the Bessemer process already described. This is done by adding to the wrought iron a certain amount of cast iron—the percentage of carbon in which is known—while it lies in the Bessemer converter where it has been made. This process is named after Sir Henry Bessemer, who introduced it in 1856. The converters are now lined with a substance called ganister, which is a compound of silicon, and whilst the liquid metal lies in them, air is blown into it by engines from below. The ordinary dose of metal for a converter may be as much as 10 tons, and this may all be converted in half an hour. No wonder that more than 30 times as much steel is now turned out as before 1856, and at only about one-fifth of the former cost.

Basic Steel. To manufacture steel from pig-iron that contains phosphorus there has been introduced a method which is a simple modification of the Bessemer process. Instead of having a silicious lining like the ordinary Bessemer converter, the basic Bessemer converter has a lining of magnesium limestone and tar. This will withstand almost any temperature that successfully effects the removal of the phosphorus.

It is still somewhat uncertain how we are to describe steel from the purely chemical point of view. The difference between steel and pig-iron, or cast iron, is certainly very much more than a mere difference in the proportion of carbon that each contains. The carbon in cast iron is not really combined with the iron. The carbon in steel is either combined with the iron or dissolved in it, and it is this that doubtless constitutes the essential difference. The objection to the presence of phosphorus in steel in quantities greater than 1 per cent. is that such steel is brittle, or *cold-short*. A still smaller percentage of sulphur also makes the steel brittle, and such steel is called *red-short*. The same applies to the presence of silicon and other impurities. Steels containing a considerable percentage of carbon—anything above ¼ per cent.—may be rendered so hard by heating to redness and sudden cooling that they will scratch glass. But very hard steel is also very brittle, and in order to remove the brittleness such steel must be annealed or softened by a second process of heating and cooling. Mild steel is now employed for all purposes for which wrought iron was formerly employed. A steel rail will last about eleven times as long as an iron one.

The Bessemer process, though it has revolutionised the whole subject of steel, is nevertheless open to certain criticism. It does not produce the purest form of steel, in order to obtain which we must go back to the cementation process already described, using the purest Swedish iron.

Iron Chemically Considered. We must now proceed to consider iron from the chemical point of view. The best way in which to obtain absolutely pure iron is by the action of hydrogen gas upon one of the oxides of iron, which the hydrogen *reduces*. To reduce a body is to take oxygen from it, hence a reducing agent itself undergoes oxidation whilst effecting the reduction of something else. But this pure iron is very unstable, for in the presence of moisture and air it rusts very rapidly, forming various compounds, such as the oxide. For practical purposes, therefore, the surface of the iron requires to be treated with something which will withstand the action of the air. Such a substance is zinc, or, rather, an alloy of zinc and iron. When thoroughly clean, wrought iron is dipped into a bath of melted zinc, which is deposited upon it. This *galvanised iron*, as it is called for some mysterious reason, is in wide use in virtue of its resistance to all atmospheric action. Similarly, the iron may be coated with tin, yielding the product of which we have lately heard a good deal, called *tin plate*.

Iron has very marked magnetic qualities. The *lodestone*, for instance, formerly used as a compass by sailors—lodestone seems to mean "leading stone"—is an oxide of iron, and has the formula Fe_3O_4. It is now usually known as magnetite, or the magnetic oxide. Other forms of iron are also capable of easy magnetisation—that is to say, they respond to the attraction of magnets, and can themselves be converted into magnets. Steel has similar properties, with greater power of maintaining the magnetic quality.

The other important oxides of iron are ferrous oxide, which has the formula FeO, and ferric oxide, which has the formula Fe_2O_3.

Difference between "ous" and "ic." Here we may explain, once and for all, the use of these two terminations "ic" and "ous." When the Romans wanted to express fulness, they made an adjective terminating with the syllable *osus*, as for instance, *amorosus*. In English, we contract this to *ous*, and this termination of English words always has the same meaning as the Latin termination *osus*. For instance, there is our word amorous. Similarly, in chemistry, whenever the salt of a base contains more of that base than another salt, we describe the first by the termination *ous*, and the second by the termination *ic*. Hence, a ferrous salt, or a mercurous, or a stannous, tells us by its name that it contains more iron or mercury or tin than a ferric salt, a mercuric or a stannic.

Other ways of expressing the proportion of the base in a salt must be noted. They consist in attaching the prefixes *per* and *sub* to the second half of the name of the salt. For instance, the salt FeCl$_2$, which contains more iron proportionately than the salt FeCl$_3$, is usually called ferrous chloride, whilst the second is called ferric chloride. But the salt may be looked at in another way. We may say that the amount of chloride in the first salt is *sub*, which means under; whilst the amount of chloride in the second salt is *per*, which means through, or thorough, as in the word perfect. Hence, another name for ferrous chloride is subchloride of iron, whilst another name for ferric chloride is perchloride of iron, and we may speak when we please of the "sub salts" and the "per salts," to distinguish the two series. Let us now make a little table giving instances of the use of these terms:

Ferric chloride, or Perchloride of iron, or FeCl$_3$.	Ferrous chloride, or Subchloride of iron, or FeCl$_2$.
Mercuric chloride, or Perchloride of mercury, or HgCl$_2$.	Mercurous chloride, or Subchloride of mercury, or HgCl.

Iron in the World of Life. We cannot leave our consideration of this metal without referring to its *rôle* in living matter. Iron is found in all the higher plants and animals; indeed, it is possible that it may occur in every living thing. It is thus an essential ingredient of the food of animals and of plants. In all the higher animals and plants—the term higher must here be taken as meaning all but the very lowest—iron gives rise to very characteristic substances which have a distinctive colour. Iron is indeed responsible for the colour of life in both the animal and the vegetable world. The characteristic colouring matter of the animal is the red of its blood. This red is due to an exceedingly complicated substance—believed by most chemists to have the most complicated molecule that is known—which is called *hæmoglobin*. In every molecule of this substance there is always one atom of iron. The process of breathing depends essentially upon the presence of this substance, which has the power of taking up oxygen from the air in the lungs, and then carrying it by means of the circulation to the tissues which need it.

The colour of life in the plant is the green of its leaves. This green substance, which is found occurring in minute granules situated at the circumference of the cells of the leaf [see BOTANY], is known as chlorophyll, and iron is an essential constituent of it. If a plant be nourished in such a fashion that no iron can gain access to it, it will come up blanched, containing no chlorophyll whatever, will very soon die, and will be unable to propagate itself. The service which the iron performs for the plant is exactly the converse of that which it performs for the animal, for whilst it enables the animal to help itself to oxygen from the air—oxygen which is then combined with carbon, and given back to the air in the form of carbonic acid, CO$_2$—it enables the plant to decompose the CO$_2$ in the air, taking the carbon into itself, as the most precious ingredient of its food, leaving the oxygen behind. Ultimately the tissues of the plant serve as food for the animal, which oxidises them by means of the oxgyen obtained in the manner we have described. So the round continues, and the reader will see that iron thus plays an all important and double part in that incessant and complementary series of chemical changes in the animal and vegetable world which has been called the cycle of life.

Carbon the Most Important Element. The next element which we have to consider is known as *carbon*. It is the most important of all the elements, and needs very detailed consideration. In the first place we must note that the chemistry of carbon has two distinct aspects, only one of which we can deal with at present. Reference has already been made to the fact that what used to be called organic chemistry is now known as the chemistry of the carbon compounds, and to that we must return later. Here we shall have quite enough to do to consider carbon in its behaviour uncombined, or forming the simplest compounds with oxygen.

Unlike the elements which we have lately been considering, carbon is not a metal. It may be obtained from compounds, such as the oxide, by means of hydrogen or potassium at a red heat, since these elements will reduce the oxide and leave free carbon behind. Perhaps the purest carbon, however, is prepared by heating sugar, which is a compound of carbon, hydrogen and oxygen. If sugar be heated to redness in a closed crucible, it is charred—that is to say, the other elements are driven off, and carbon alone remains.

But carbon occurs in nature in the uncombined state, or, rather, in several states. The *diamond* is a form of carbon, so is *charcoal*, and so is *graphite* (from the Greek *grapho*, I write), which is the so-called lead of lead-pencils. Now, this fact—that carbon may exist in such widely different forms—is an illustration of a general property which many substances possess, and which we cannot do better than digress to discuss here.

Allotropy. Allotropy is the name applied to this property. It is sometimes also called physical isomerism. Chemically, the substance in question is the same in each case. Physically, it differs profoundly; sometimes it is crystalline, as in the case of the diamond; sometimes it forms crystals of an entirely different kind, such as graphite; and sometimes it is not crystalline at all, like charcoal. The technical name for a substance which is not crystalline is *amorphous*, literally meaning shapeless. Other elements have this property of allotropy besides carbon, instances being phosphorus and sulphur; and numerous compounds have the same property, such as silica, the oxide of silicon, which occurs in the amorphous state, and also in crystalline forms, such as the agate and quartz. The explanation of allotropy is hard to discover; perhaps the most obvious fact connected with it is that the change of physical state usually depends upon a change in temperature. Let us now return to the various allotropic forms of carbon.

Continued

LATIN—ENGLISH—FRENCH—GERMAN

Latin and English by G. K. Hibbert, M.A.; French by Louis A. Barbé, B.A.; German by P. G. Konody and Dr. Osten

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LATIN

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By Gerald K. Hibbert, M.A.

SECTION I. GRAMMAR

Frequentative Verbs. These express repeated or intenser action, and are formed either (1) in *-to*, *-so*, from supine stems—*e.g.*, *tracto* = I handle (from *traho*, *traxi*, *tractum* = I draw); *curso* = I run about (from *curro*, *cucurri*, *cursum* = I run); or (2) by adding *-ito* to the last consonant of the present stem—*e.g.*, *rogito* = I ask often. All Frequentatives are first conjugation.

Inceptive Verbs. These express beginning of action, and are formed by adding *-sco* to the present stem of verbs, or from nouns by adding *-asco* or *-esco*—*e.g.*, *juvenesco* = I begin to grow young; *ignesco* = I burst into flame. All these are third conjugation.

Desiderative Verbs. These express desire, and are formed by adding *-urio* to the supine stem—*e.g.*, *esurio* = I am hungry (from *edo*, *esum* = I eat). All these are fourth conjugation.

Quasi-Passive Verbs. These are the exact opposite of Deponents. Deponents are passive in form and active in meaning; Quasi-Passives are active in form and passive in meaning—*e.g.*, *fio* = I am made; *exulo* = I am banished; *liceo* = I am put to auction; *vapulo* = I am beaten; *veneo* (compound of *eo* = I go) = I am on sale (used as the passive of *vendo* = I sell).

Defective Verbs. These lack some of a verb's usual parts:

1. *Odi* (I hate), *memini* (I remember), *cœpi* (I begin), are perfects, without any present-stem tenses. *Novi* (I know), from *nosco*, is similarly used. Thus: "To hate" = *odisse*; "I remembered" = *memineram* (pluperfect).

Memini has Imperative *memento*, *mementote*.

Cœpi and *odi* have perfect and future participles—*cœptus* and *cœpturus*, *osus* and *osurus*.

2. Many verbs have perfect without supine, and some have neither perfect nor supine—*e.g.*, most of the Inceptive verbs.

3. *Inquam* (I say) has the following parts:

	1.	2.	3.
Present:	inquam	inquis	inquit
	inquimus	inquitis	inquiunt
Imperfect:	—	—	inquiebat
	—	—	inquiebant
Future:	—	inquies	inquiet
Perfect:	—	inquisti	inquit
Imperative:	—	inque	—
	—	inquite	—

Aio (I say ay, I affirm) has:

	1.	2.	3.
Present:	aio	ais	ait
	—	—	aiunt
Imperfect:	aiebam (complete)		
Pres. subj.:	—	aias	aiat
	—	—	aiant

Fari (to speak)—deponent—has: *Fatur* (he speaks); *fabor* (I shall speak); *fare* (speak thou); *fari*, *fatus*, *fandus*.

Impersonal Verbs. These are conjugated only in the third person singular of the finite verb, and in the infinitive. They can be in any tense.

1. The following are used with the accusative: *Oportet* (it behoves), *decet* (it beseems), *dedecet* (it misbeseems), *piget* (it irks), *pudet* (it shames), *poenitet* (it repents), *taedet* (it wearies), *miseret* (it moves pity)—all second conjugation; also, *delectat* (it charms), and *juvat* (it delights)—first conjugation.

2. The following are used with the dative: *Libet* (it pleases), *licet* (it is lawful), *liquet* (it is clear)—second conjugation; also, *accidit*, *contingit* (third), *evenit*, *convenit*, *expedit* (fourth).

Examples: *Oportet me ire* = I must go. *Licuit tibi ridere* = You were allowed to laugh.

3. *Pudet*, *piget*, *taedet*, *poenitet*, *miseret*, are used with an acc. of the person feeling, and a genitive of what causes the feeling: *Taedet me vitae* = I am weary of life. *Tui me miseret*; *mei piget* = I pity you; I am vexed with myself.

4. *Interest* and *refert* (it concerns, or it is important for) take the *genitive* of the person concerned—*e.g.*, *Caesaris interest pontem facere* = it is Cæsar's interest to build a bridge. [This construction is rare with *refert*: say, *ad Cœsarem refert*.] But *possessive pronouns* are used in the *ablative feminine*—*e.g.*, *Quid meā refert* = What does it signify to me? *Magis nullius interest quam tuā* = It concerns no one more than yourself*.

Irregular Verbs: First Conjugation. The following are the most important exceptions:

Perfect—*ui*. Supine—*itum*.

crepo	crepare	crepui	crepitum	*creak*

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* The *meā* and the *tuā* probably agree with *re* understood. *Meā re fert* was originally *meae rei fert*, and then *rei* being shortened to *re*, *meae* became *mea*. If this is so, *mea interest* is probably an imitation.

Similarly, *cubo* (*lie down*), *domo* (*tame*), *plico* (*fold*), *sono* (*sound*), *tono* (*thunder*), *veto* (*forbid*).

Perfect—*ui*. Supine—*tum*.

seco	secare	secui	sectum	*cut*

Perfect reduplicated. Supine—*tum*.

do	dare	dedi	datum	*give*
sto	stare	steti	statum	*stand*

Perfect—*vi*. Supine—*tum*.

juvo	juvare	juvi	jutum	*help*
lavo	lavare	lavi	lotum *or* lavatum	*wash*

NOTE. Compounds of *do* are of third conjugation, and make *-didi*, *-ditum* (except *circumdo*, *pessumdo*, and *venumdo*, which make *-dedi*, *-datum*). Compounds of *sto* form *-stiti*, *-stitum*.

SECTION II. COMPOSITION

The Oratio Obliqua. This construction, known also as Oblique Narration, or the Accusative and Infinitive Construction, is one of the most characteristic idioms of Latin. It is especially used where English has a clause beginning with *that* after (1) verbs of *saying*, *knowing*, *thinking*, *believing*, *feeling*; (2) impersonal expressions, as "It is clear, true," etc.

Rule 1. The subject is put in the acc. case, and all principal verbs are changed from indicative to infinitive, retaining their original tenses—*e.g.*, He says that the moon is smaller than the sun = *dicit lunam esse minorem sole* (literally, He says the moon to be smaller). I know that I shall die = *scio me moriturum esse*.

[Instead of *dico* . . . *non*, Latin uses *nego* = I deny—*e.g.*, He said he did not believe = *negavit se credere*.]

Rule 2. All verbs, other than principal verbs (*i.e.*, verbs directly making a statement), are put in the subjunctive. There cannot be an indicative in Oratio Obliqua. This is very important.

Examples: "The slaves whom I now have here are most faithful" is in Oratio Recta (Direct Narration), and would be in Latin, "Servi quos nunc hic *habeo* sunt fidelissimi." Turn this into "reported speech," or Oratio Obliqua, and we have "He said that the slaves whom he then had there were most faithful" = dixit servos quos tum ibi *haberet* esse fidelissimos. [Note the change of "now" into "then," "here" into "there," "I" into "he," "have" into "had," and "are" into "were"; but we still use "esse" for "were," because "esse" is both present and imperfect infinitive, and "fuisse" would mean "had been."] Again, "It is clear that, because the citizens are cowards, the city will be taken" = manifestum est quod cives ignavi *sint*, urbem captum iri.

Rule 3. Imperatives in Oratio Recta become imperfect subjunctive in Oratio Obliqua—*e.g.*, *Recta*: "Charge, my men," said the general = *Instate, milites, inquit imperator*. *Obliqua*: "The general said to his soldiers, 'Let them charge,'" = imperator militibus dixit, Instarent.

Rule 4. Questions in the first and third persons are rendered in Oratio Obliqua by the accusative of the person and the infinitive of the verb; but questions of the second person become imperfect or pluperfect subjunctive—*e.g.*, (They said) Why is our general absent? = *cur abesse imperatorem?* (He said) Why are you advancing? = *cur progrederentur?*

Rule 5. *Ego*, *tu*, *nos*, *vos*, cannot find a place in Oratio Obliqua; *me* and *nos* become *se*, *tu* becomes *ille*, and *vos* becomes *illi*.

Se and *suus* refer, as a rule, to the speaker—*e.g.*, He says that he will come = *dicit se venturum esse*.

He said, "Let them not forget his kindnesses" = *ne suorum beneficiorum obliviscerentur*.

If, however, *suus* is wanted to refer to the subject of some subordinate verb (*e.g.*, *obliviscerentur*, above), then *ipse* is used to refer to the speaker—*e.g.*, Let them not forget their own cowardice or his kindnesses = *ne suae ignaviae aut ipsius beneficiorum obliviscerentur*.

NOTE. The translation of the English conjunction *that* needs great care. When it means "in order that," "so that" (as "He walked fast that he might warm himself"), it should be translated by *ut* with subjunctive. When it means "the fact that," after any verb or phrase *sentiendi vel declarandi* ("of feeling or stating") the accusative with the infinitive must be used. In English we can say, "You were ill, he thought, and therefore absent." But in Latin we must say, "He thought that you were ill, etc." (*Putavit te aegrotare*).

TO BE TURNED INTO LATIN PROSE.

The inhabitants of this island were so bold that they would have preferred a thousand deaths (*say*, "to die six hundred times") to disgrace, if the choice had been necessary. One brave farmer was asked why he would sooner die nobly on the field of battle than live ignobly at home. He answered, "Because I am more afraid of shame than of death." It happened once that they were invaded by the powerful nation of the Ventidii, who landed on their shores, marched up to their capital, devastated the country all round, and then laid siege to the city. The citizens determined to resist with boldness. Instead of throwing themselves at their enemies' feet, they sent away their families, their old men, and their treasures, and prepared to resist with desperation. Though they were prevented by scruples from committing suicide, they promised one another to fight so desperately that the enemy should not take them alive. When they were all assembled in arms, their general addressed them thus: "Remember, citizens, that victory or death awaits you. I will say no more; the enemy is at the gates. What reason is there for delaying?"

LATIN VERSION OF THE ABOVE EXTRACT.

[Latin prose composition can be learned only by long and constant practice. The student is advised to translate the following Latin version *literally* into English, and then compare his English version with the English version as given above. This will give him a good idea of the difference between the English and the Latin ways of expressing ideas. Accuracy and clearness are the first essentials, and then the style should be polished by constant comparison with the style of the best Latin authors, such as Livy and Cicero. Hints on style will be given from time to time during the remainder of this course.]

Qui in hac insula habitabant ii omnes quum essent summa audacia præditi, sescentiens mortem quam semel, si optandum fuisset (*gerundive* = "if it had to be chosen, if choice had to be made") infamiam obire maluissent. E quibus agricola quidam, vir fortissimus, rogatus cur potius vellet militiæ per virtutem emori quam per dedecus domi vivere, respondit se ignominiam magis quam mortem timere. Quibus ita accidit ut Ventidii, quæ gens erat potentissima, in eorum fines navibus ingressi, agris undique vastatis, urbem quam maximam habebant obsiderent. Sed quum civibus visum esset sibi quam acerrime hostibus obstandum (gerundive), tantum aberat ut se iis ad pedes dejicerent ut, pecuniis et liberis et senibus dimissis, sese ad resistendum accingerent ut (as) qui de suis rebus desperarent. Religione quidem obstricti quominus sibi mortem consciscerent, alii tamen aliis pollicebantur sese acrius pugnaturos quam qui ab hostibus vivi caperentur. Quos quum armatos imperator convocasset (shortened form of *convocavisset*), jussit meminisse aut victoriam aut mortem obeundam: se non plura dicturum; hostes illis ad portas adesse: quid causæ (partitive genitive, literally "what of reason") esse cur jam morarentur?

SECTION III. TRANSLATION

PERORATION OF CICERO'S SECOND PHILIPPIC SPEECH.

Respice, quæso, aliquando rempublicam, M. Antoni: quibus ortus sis, non quibuscum vivas considera: mecum, ut voles: redi cum republica in gratiam. Sed de te tu videris: ego de me ipso profitebor. Defendi rempublicam adolescens, non deseram senex: contempsi Catilinæ gladios, non pertimescam tuos. Quin etiam corpus libenter obtulerim, si repræsentari morte mea libertas civitatis potest: ut aliquando dolor populi Romani pariat, quod jam diu parturit. Etenim si abhinc annos prope viginti hoc ipso in templo negavi posse mortem immaturam esse consulari, quanto verius nunc negabo seni? Mihi vero, patres conscripti, jam etiam optanda mors est, *perfuncto** rebus iis quas adeptus sum quasque gessi. Duo modo hæc opto; unum ut moriens populum Romanum liberum relinquam—hoc mihi majus ab dis immortalibus dari nihil potest—alterum, ut ita cuique eveniat ut de republica quisque mereatur.

* "Perfuncto" is dat. of the perf. ptc., agreeing with "mihi": it governs an abl., being compound of "fungor."

●

ENGLISH VERSION OF ABOVE.

Bethink yourself of the State, I beseech you, even now, Marcus Antonius: think of those from whom you have sprung, not of those with whom you now associate: deal with me as you like, but make up your quarrel with the State. About your own course, however, you yourself will decide: I will openly profess my own. I defended the State in my youth, I will not abandon it in my age: I scorned the swords of Catiline, I will not fear yours. Nay, rather, I would gladly offer my body, if by my death the freedom of the State can be immediately recovered, so that at last the pangs of the Roman people may give birth to that with which they have so long been in travail. If, nearly twenty years ago, I said in this very temple that death could not be untimely for one who had filled the consulship, how much more truly shall I say this now of an old man! For me indeed, Senators, death is even to be desired, now that I have completed the course of honour and of achievement.

I have only two wishes. One is that at my death I may leave the Roman people free—and no greater gift than this could be granted me by Heaven! The other is that as each man has deserved of the State, such may be that man's reward.

Continued

ENGLISH

Continued from page 905

By Gerald K. Hibbert, M.A.

THE VERB—*continued*

Strong and Weak Conjugations. English verbs are divided into *strong* and *weak*, according to the manner in which they form their Past Indefinite tense.

1. Verbs that form this tense by modifying the vowel of the present tense (without adding any suffix) are said to belong to the *strong* conjugation—as: *shine, shone.* The past participle of all strong verbs originally ended in *-en*, and this ending still remains in many of them (sometimes in the form of *-n*)—as: *break, broke, broken.* The past tense of strong verbs arises from contraction of the original reduplicated form; for this tense was at first formed by reduplication—*i.e.*, by repeating the root of the verb (*cf.* in Latin, *fallo, fefelli,* where the reduplication modifies the root vowel from *a* to *e*). With a few exceptions, all strong verbs are of one syllable only. The exceptions are really compounds of simple verbs, as *forget, beget, awake, abide,* etc.

2. Verbs that form their past indefinite by adding the suffix *-ed*, *-d*, or *-t* to the present tense are said to belong to the *weak conjugation*—as: *treat, treated*; *feel, felt.* When the present tense ends in *e, d* only is added—as, *love, loved.* The vowel *y* preceded by a consonant becomes *i* before this suffix—as: *bully, bullied*; *pay, paid.* A single final consonant preceded by a single vowel is usually doubled before the suffix—as: *drug, drugged*; *travel, travelled.* The

past participle of weak verbs is usually the same in form as the past indefinite. If the present tense ends in *d* or *t*, the suffix is often dropped, and present, past, and past participle have all the same form—as: *cost, cost, cost.*

All the verbs in the Strong Conjugation are of old Teutonic stock. The Weak Conjugation, while including some old verbs and some that were once Strong, is mainly composed of the verbs added at later times—*e.g.*, at the Norman Conquest. Every new verb now added to the language belongs to this conjugation—as: *telephoned, motored, electrified, photographed.*

It is needless to give here a list of all the Strong and the Weak Verbs in the English language. The most interesting verbs, however, and those that present any difficulty, are now given.

Verbs of the Strong Conjugation.

1.

Present.	*Past.*	*Past Participle.*
bind	bound	bound
find	found	found
grind	ground	ground
cling	clung	clung
fling	flung	flung
sling	slung	slung
slink	slunk	slunk
stick(*a*)	stuck	stuck
string	strung	strung
swing	swung	swung
wring	wrung	wrung
begin	began, *or* begun(*b*)	begun
drink	drank, *or* drunk(*b*)	drunk, *or* drunken(*c*)
ring	rang, *or* rung(*b*)	rung
sing	sang, *or* sung(*b*)	sung
sink	sank, *or* sunk(*b*)	sunk, *or* sunken(*c*)
spin	span, *or* spun	spun
shrink	shrank, *or* shrunk(*b*)	shrunk, *or* shrunken(*c*)
spring	sprang, *or* sprung(*b*)	sprung
stink	stank, *or* stunk(*b*)	stunk
swim	swam, *or* swum (*b*)	swum
win	won [old form, *wan*]	won
wind	wound	wound

NOTES. (*a*) *Stick*, now strong, was formerly weak.

(*b*) These forms are not often used now.

(*c*) *Drunken*, *sunken*, and *shrunken* are now used only as adjectives—as: a *drunken* man; *sunken* rocks; *shrunken* flannel.

2.

Present.	*Past.*	*Past Participle.*
blow	blew	blown
grow	grew	grown
know	knew	known
throw	threw	thrown
draw	drew	drawn
hold	held	holden, *or* held
fall	fell	fallen
lie (to recline)	lay	lain
slay	slew	slain
see	saw	seen
drive	drove [old form, *drave*]	driven
ride	rode	ridden
rise	rose	risen
smite	smote	smitten
chide	chid [old form, *chode*]	chidden, *or* chid
hide	hid	hidden, *or* hid
slide	slid	slidden, *or* slid
strive	strove	striven
strike	struck	stricken, *or* struck
thrive	throve	thriven
write	wrote	written
bite	bit	bitten
eat	ate	eaten
beat	beat	beaten
bid (*to order*)	bade, *or* bid	bidden, *or* bid
give	gave	given
forsake	forsook	forsaken
shake	shook	shaken
take	took	taken
come	came	come
bear	bore, *or* bare	borne, *or* born
break	broke, *or* brake	broken
tear	tore, *or* tare	torn
wear	wore	worn
weave	wove	woven
speak	spoke, *or* spake	spoken
steal	stole	stolen
swear	swore, *or* sware	sworn
choose	chose	chosen
freeze	froze	frozen
fly	flew	flown

NOTES. *Fall, fell, fallen* is intransitive; but the kindred verb *to fell* is transitive, and regular of the weak conjugation—as: "The woodman *felled* the tree." *Bare, brake, tare, spake, sware* are not used in modern English.

Borne means *carried*; *born* is used of *birth*, chiefly after the verb "to be." Examples: "Which have *borne* the burden and heat of the day" (St. Matthew); "Where is He that is *born* King of the Jews?" (St. Matthew).

3.

Present.	*Past.*	*Past Participle.*
abide	abode	abode
awake	awoke	awoke
stand	stood	stood
tread	trod	trod, *or* trodden
sit	sat	sat
get	got (gat)	got (gotten)
hang	hung	hung
run	ran	run
burst	burst	burst
shoot	shot	shot
seethe	sod	sodden, *or* sod
spit	spat, *or* spit	spit
fight	fought	fought

NOTES. *Awake*, as a strong verb, is intransitive, meaning "I wake up." When it is transitive, meaning "I rouse some-one," it is weak, and has *awaked, awaked* for its past tense and past participle. Similarly with *hang;* when intransitive it is strong—as: “ He *hung* there for three hours ” ; when transitive, it is weak—as: “ But he *hanged* the chief baker.”

Seethe, meaning *to boil,* is very seldom used now, except in a figurative sense—as: “ A seething mass of men.” The original sense is seen in the expression, “ And Jacob *sod* pottage ” (Genesis). The past participle *sodden* now means “ soaked through.” *Seethe* is now usually weak, making *seethed, seethed.*

Verbs of the Weak Conjugation. 1. Some lose the suffix and shorten the vowel—as:

Pres.	*Past.*	*P.Part.*	*Pres.*	*Past.*	*P. Part.*
bleed	bled	bled	meet	met	met
breed	bred	bred	read	read*	read*
feed	fed	fed	speed	sped	sped
lead	led	led	light	lit	lit

* Pronounced *rĕd.*

2. Some lose the suffix without changing the vowel; but they change the final *-d* into *-t :*

Present.	*Past.*	*Past Participle.*
bend	bent	bent
lend	lent	lent
rend	rent	rent
send	sent	sent
spend	spent	spent
wend	went, *or* wended	wended
build	built	built, *or* builded
blend	blended	blent
gild	gilt, *or* gilded	gilt, *or* gilded
gird	girt, *or* girded	girt, *or* girded

3. Some lose the suffix and show no change at all. The following have the same form throughout: *Cast, cost, cut, hit, hurt, knit, let, put, rid, set, shed, shred, shut, slit, split, spread, thrust,* and *bid* (meaning “ to offer at an auction,” as “ He *bid* £5 for it yesterday ”). *Let,* meaning *to hinder,* comes from *lettan* (to hinder, *cf. late*), while *let,* meaning *to allow,* is from *laetan* (French *laisser*).

4. Some retain the suffix, but shorten or otherwise alter the vowel:

Present.	*Past.*	*Past Participle.*
beseech	besought	besought
buy	bought	bought
catch	caught	caught
bring	brought	brought
sell	sold	sold
seek	sought	sought
teach	taught	taught
think	thought	thought
tell	told	told
work	wrought	wrought
can	could	—
may	might	—
will	would	—
shall	should	—
bereave	bereft, *or* bereaved	bereft
creep	crept	crept
deal	dealt	dealt
dream	dreamt, *or* dreamed	dreamt
feel	felt	felt
flee	fled	fled
hear	heard	heard
keep	kept	kept
kneel	knelt	knelt
lean	leant, *or* leaned	leant
leave	left	left
lose	lost	lost
mean	meant	meant
sleep	slept	slept
sweep	swept	swept
weep	wept	wept
lay	laid	laid
say	said	said
shoe	shod	shod

Verbs of Mixed Conjugation. Some verbs are found in both conjugations, while others either combine a weak past participle with a strong past tense, or a strong past participle with a weak past tense.

Present.	*Past.*	*Past Participle.*
shear	shore	shorn
	sheared	sheared
climb	clomb	—
	climbed	climbed
cleave	clove	cloven
(= to split)	clave	
	cleft	cleft
heave	hove	hoven
	heaved	heaved
dig	dug	dug
	digged	digged
crow	crew	crowed
	crowed	
help	helped	holpen
		helped
hew	hewed	hewn
		hewed
lade	laded	laden
lose	lost	lost, lorn (as in *forlorn*)
melt	melted	molten
		melted
mow	mowed	mown
		mowed
rive	rived	riven
		rived
saw	sawed	sawn
		sawed
shape	shaped	shapen
		shaped
shave	shaved	shaven
		shaved
shew, *or* show	shewed, *or* showed	shewn, shown, *or* shewed, showed
sow	sowed	sown
		sowed
strew	strewed	strewn, strown
		strewed
swell	swelled	swollen
		swelled
wash	washed	washen
		washed

Present.	*Past.*	*Past Participle.*
wax (= to grow)	waxed	waxen waxed
do	did	done
go	[went]	gone

NOTES. *Went*, used as the past tense of *go*, is the past tense of *wend*—as in "to wend one's way."

Crew (from *crow*) is rarely used now, and only of the literal crowing of a cock—*e.g.*, "the cock *crew*." When used of the crowing of babies, etc., the past tense is always *crowed*.

Many of the above forms are now obsolete—*e.g.*, *holpen* ("He hath holpen his servant Israel"), *hoven*, *washen*, *waxen* ("The children of Israel were *waxen* strong"); and some of the past participles are used only as adjectives—*e.g.*, a *molten* image, the *cloven* hoof, a *shaven* head.

Clothe, *have*, and *make* form *clad*, *had*, and *made*, which are contracted from *clothed*, *haved*, and *maked*.

Tight, *straight*, *dight* (adjectives) are weak past participles of *tie*, *stretch*, *deck* (= to *adorn*). *Distraught* is an irregular past participle of *distract*. *Fraught* is sometimes said to be the participle of "to freight," but probably it is not connected with any verb.

"Lie" and "Lay." So much confusion is prevalent concerning these two verbs that a special paragraph seems needful in this connection. We can leave out of consideration *to lie*, meaning *to tell an untruth*; for this verb is of the weak conjugation and perfectly regular, *lie*, *lied*, *lied*.

Examples: "He *lied* like a trooper," "You have *lied* to me more than once."

The confusion arises between *to lay* and *to lie* (meaning *to recline*), because the past tense of *lie* in this sense is *lay*. Let us compare the principal parts of the two verbs.

Present.	*Past.*	*Past. Part.*
lie	lay	lain
lay	laid	laid

To lie is strong and *intransitive*; therefore, it cannot govern an object or be used in the passive voice. *To lay* is weak and *transitive*; therefore it must have an object expressed.

Examples: "He *lay* there for several hours," "I have never *lain* on a softer bed," "That hen *laid* an egg yesterday," "Having *laid* His hands upon them, He blessed them." Of course, we can say either "They *lay* down" or "They *laid themselves* down"; the meaning is practically the same in either sentence, but the verb in the first is intransitive, and in the second transitive (with *themselves* as object).

EXERCISE.

Correct, *if necessary*, the following sentences:

1. I will both lay me down in peace, and sleep.
2. We ought to lay down our lives for the brethren.
3. I am going to lay down.
4. He lied when he said that he had lain his work aside and had laid down all the afternoon.
5. Having lain motionless for some time, I began stealthily to creep along.
6. When he has laid his burden down, he will be a different man.
7. Lay here and rest; lay your head upon this pillow.
8. It has been laid upon me that I ought to go.

Continued

FRENCH

Continued from page 907

By Louis A. Barbé, B.A.

NOUNS AND ADJECTIVES

The Feminine

1. Certain nouns have masculine and feminine forms consisting of wholly different words, as in English. The chief of these are:

Masculine.	*Feminine.*
bélier, ram	*brebis*, ewe
bouc, he-goat	*chèvre*, she-goat
cerf, stag	*biche*, hind
cheval, horse	*jument*, mare
cochon, pig	*truie*, sow
compère, gossip	*commère*, gossip.
coq, cock	*poule*, hen
garçon, boy	*fille*, girl
gendre, son-in-law	*bru*, daughter-in-law
homme, man.	*femme*, woman
jars, gander	*oie*, goose
lièvre, hare	*hase*, doe-hare
mâle, male	*femelle*, female
monsieur, gentleman	*dame*, lady
neveu, nephew	*nièce*, niece
oncle, uncle	*tante*, aunt.
papa, papa	*maman*, mamma
parrain, godfather	*marraine*, godmother
père, father	*mère*, mother
roi, king	*reine*, queen
taureau, bull	*vache*, cow

2. Certain feminine forms retain the masculine stem, but are irregular in their termination:

Masculine.	*Feminine.*
ambassadeur, ambassador	*ambassadrice*, amb- sadr
canard, drake	*cane*, duck
compagnon, companion	*compagne*, companion
devin, soothsayer	*devineresse*, soothsayer
dieu, god	*déesse*, goddess
dindon, turkey	*dinde*, turkey-hen
duc, duke	*duchesse*, duchess
empereur, emperor	*impératrice*, empress
gouverneur, governor	*gouvernante*, governess
héros, hero	*héroine*, heroine
loup, wolf	*louve*, she-wolf
mulet, mule	*mule*, mule
perroquet parrot	*perruche*, parrot
poulain, foal	*pouliche*, filly
serviteur, servant	*servante*, servant

3. **The names of many animals have only one form. In that case, when there is any necessity for indicating the difference of sex, it is done by adding the words *mâle* or *femelle*.**

Formation of the Feminine

Such nouns as have feminine forms follow the same rules as adjectives for the formation of the feminine. These rules are as follow :

1. **To form the feminine of nouns and adjectives add a mute *e* to the masculine : *grand, grande,*** large ; ***petit, petite,*** small ; ***marquis, marquise,*** marquess ; *ami, amie,* friend.

2. If the masculine ends in mute *e* no change takes place : *jeune* (m. and f.), young ; *aimable* (m. and f.), amiable.

Exceptions : The following nouns, ending in mute *e*, form their feminine by changing *e* into *esse* :

âne	ass	*ânesse*
chanoine	canon	*chanoinesse*
comte	count	*comtesse*
druide	druid	*druidesse*
hôte	host	*hôtesse*
maître	master	*maîtresse*
mulâtre	mulatto	*mulâtresse*
nègre	negro	*négresse*
prêtre	priest	*prêtresse*
prince	prince	*princesse*
prophète	prophet	*prophétesse*
tigre	tiger	*tigresse*
traître	traitor	*traîtresse*

When *mulâtre* and *nègre* are used as adjectives they have the same form for both genders.

3. Nouns and adjectives ending in *el, eil, en, ien, on, et* in the masculine, form their feminine by doubling the final consonant and adding mute *e* : *mortel, mortelle,* mortal ; *pareil, pareille,* similar ; *européen, européenne,* European ; *musicien, musicienne,* musician ; *mignon, mignonne,* dainty ; *muet, muette,* mute.

Exceptions : The following adjectives in *et*, instead of doubling the *t* before adding mute *e*, take a grave accent on the *e* that precedes it :

complet	complete	***complète***
incomplet	incomplete	***incomplète***
concret	concrete	***concrète***
discret	discreet	***discrète***
indiscret	indiscreet	***indiscrète***
inquiet	anxious	***inquiète***
replet	corpulent	***replète***
secret	secret	***secrète***

4. **The following adjectives also form their feminine by doubling the final consonant and adding mute *e* :**

bas	low	***basse***
épais	thick	***épaisse***
exprès	express	***expresse***
gentil	pretty	***gentille***
gras	fat	***grasse***
gros	big	***grosse***
las	tired	***lasse***
nul	null	***nulle***
pâlot	palish	***pâlotte***
paysan	peasant	***paysanne***
vieillot	oldish	***vieillotte***

5. The five adjectives, ***beau, nouveau, fou, mou,*** and ***vieux***, which are used only before nouns beginning with a consonant or aspirated ***h***, have a second masculine form, ***bel, nouvel, fol, mol,*** and ***vieil***, which is used before a vowel or silent ***h***. The second masculine form of these adjectives is *not* required in the plural, because there the final *x* or *s* prevents any harshness of sound before a vowel. Thus, the plural form of *beau* and of *bel* is *beaux*. The feminine is got from this second form by doubling the final *l* and adding a mute *e*.

beau, bel	beautiful	*belle*
nouveau, nouvel	new	*nouvelle*
fou, fol	mad	*folle*
mou, mol	soft	*molle*
vieux, vieil	old	*vieille*

6. Nouns and adjectives ending in *er* form their feminine by putting a grave accent on the *e* preceding the *r*, and adding mute *e* : *léger, légère,* light ; *premier, première,* first ; *berger, bergère,* shepherd ; *laitier, laitière,* milkman.

7. The feminine of adjectives ending in *gu* is formed by adding a mute *e* with a diæresis (*ë*): *aigu, aiguë,* sharp ; *ambigu, ambiguë,* ambiguous.

8. The feminine of adjectives ending in *f* changes *f* into *ve*: *vif, vive,* lively; *bref, brève* short; *neuf, neuve,* new.

9. The feminine of adjectives ending in *x* is formed by changing *x* into *se* : *heureux, heureuse,* happy ; *jaloux, jalouse,* jealous.

Exceptions :

doux	*douce*	sweet
faux	*fausse*	false
préfix	*préfixe*	prefixed
roux	*rousse*	red-haired
vieux	*vieille*	old

10. Of the few adjectives ending in *c* the following three form their feminine by changing c into *che* :

blanc	*blanche*	white
franc	*franche*	frank
sec	*sèche*	dry

The others change c into *que* :

caduc	*caduque*	decrepit
public	*publique*	public
turc	*turque*	Turkish

Grec, Greek, retains the c, *grecque* When *franc* means Frankish, its feminine is *franque*.

11 Nouns and adjectives ending in *eur* form their feminine in four different ways :

(*a*) Nouns and adjectives in *eur* derived directly from the present participle of verbs by changing ***ant*** into ***eur***, form their feminine by changing ***eur*** into *euse*: ***trompeur, trompeuse*** deceitful; ***boudeur, boudeuse,*** sulky , ***danseur, danseuse,*** dancer ; ***pêcheur, pêcheuse,*** fisher.

(*b*) **Nouns and adjectives ending in *eur* preceded by *t* (*teur*), in which the *t* belongs to the ending and not to the stem of the word, form their feminine by changing *teur* into *trice*. Many of them have corresponding English forms in tor : *acteur, actrice,* actor : *conducteur, conductrice,* conductor ; *créateur créatrice,* creator ; *exécuteur, exécutrice,* executor. This rule does not** apply to such words as the following, in which the *t* belongs to the stem: *acheteur, acheteuse*, buyer: *menteur, menteuse*, liar; *flatteur, flatteuse*, flatterer; *porteur, porteuse*, bearer

(*c*) Nouns and adjectives ending in *érieur* (= English *erior*), together with the three words *meilleur*, better; *majeur*, major, and *mineur*, minor, form their feminine regularly by the addition of mute *e*: *supérieur, supérieure*, superior; *inférieur, inférieure*, inferior.

(*d*) Some words in *eur*, that may be used both as adjectives and as nouns, form their feminine by changing *eur* into *eresse*. They are:

enchanteur	*enchanteresse*	enchanting
pécheur	*pécheresse*	sinner
vengeur	*vengeresse*	avenger

In legal phraseology *défendeur* and *demandeur*, defendant and plaintiff, have the feminine forms *défenderesse* and *demanderesse*.

The ordinary feminine of *chanteur* is *chanteuse*, but when applied to a professional singer it is *cantatrice*. *Chasseur*, hunter, if ever used in the feminine, has both *chasseuse* and *chasseresse*. The latter form is poetical, and occurs almost exclusively in connection with Diana and her nymphs. *Imposteur* has no feminine form as a noun, and is never used in the feminine as an adjective.

(*e*) The following forms do not come under any special rule:

long	*longue*	long
oblong	*oblongue*	oblong
bénin	*bénigne*	benign
malin	*maligne*	malicious (sly)
coi	*coite*	still (snug)
favori	*favorite*	favourite
frais	*fraîche*	fresh

(*f*) *Tiers*, an old form of the ordinal numeral, third (now *troisième*), is still used in a few expressions, and has *tierce* as its feminine—*e.g.*, *une tierce personne*, a third party.

Hébreue, as the feminine of *hébreu*, Jewish, is seldom used; it is only applicable to persons, and is practically superseded by *juive*, Jewish. In any other case, the feminine form *hébraïque* is used—*e.g.*, *la langue hébraïque*, the Hebrew language.

When the feminine form of a noun or of an adjective requires a grave accent it is for the purpose of preventing two mute syllables, that is, two syllables ending with a mute *e*, from coming together, thus: *sec, sè-che*; *bref brè-ve*; *berger, bergè-re*; *secret, secrè-te*.

In *exprès* the grave accent of the masculine form disappears in the feminine because the open sound which it gives the *e* is obtained by the addition of *se*, and it consequently becomes superfluous.

The diæresis on the mute *e* of such feminine forms as *aiguë* indicates that the sound of the *u* is to be retained. Without it the *g* alone would be heard as in the English word "egg."

The addition of mute *e* to a noun or adjective ending with a consonant causes the final, which is frequently silent in the masculine, to be distinctly heard, thus *savan(t)*, *savant(e)*, learned. In the case of a vowel ending, the mute *e* slightly lengthens the vowel sound, thus: *joli, jolie*, pretty; *ami, amie*, friend

The plural of the feminine forms is formed like that of the masculine by adding *s*: *Les poires sont bonnes*, the pears are good.

Adjectives agree in gender and number with the nouns which they qualify, thus: *l'arbre est haut, les arbres sont hauts*; *la belle fleur, les belles fleurs*.

Continued

GERMAN

Continued from page 750

By P. G. Konody and Dr. Osten

Gender of Nouns

VII. In German the following are of MASCULINE GENDER:

(*a*) the substantives, denoting male persons and animals, and many inanimate objects;

(*b*) the names of the seasons, months, days, and stones;

(*c*) all nouns ending in m, except those of Latin origin.

EXAMPLES. (*a*) der Sohn, son: der Bruder, brother; der Onkel, uncle; der Knabe, boy; der Greis, old man (greybeard); der Löwe, lion; der Tiger, tiger; der Bär, bear; der Wolf, wolf; der Adler, eagle; der Falke, falcon; der Sperling, sparrow; der Berg, mountain; der Fluſs, river; der Baum, tree; der Wind, wind.

(*b*) der Frühling, Spring; der Sommer, Summer; der Herbſt, Autumn; der Winter, Winter; der Monat, month; Jänner (also Januar), January; der Februar, February; der März, March; der April, April; der Mai, May; der Juni, June; der Juli, July; der Auguſt, August; der September, September; der Oktober, October; der November, November; der Dezember, December; but das Jahr (*n.*), the year; die Woche (*f.*), the week; der Tag, the day; and die Nacht, the night; der Montag, Monday; der Dienſtag, Tuesday; der Mittwoch, Donnerſtag, Freitag, Samſtag (or Sonnabend), Sonntag, (Wednesday, Thursday, Friday, Saturday, Sunday);—der Stein, stone; der Diamant, diamond; der Rubin, ruby; der Smaragd, emerald; der Kieſel, pebble; der Marmor, marble; der Granit, granite.

(*c*) der Sturm, storm; der Schwarm, swarm; der Arm, arm; der Wurm, worm; der Lärm, noise; der Atem (or Odem), breath.

EXCEPTIONS: die Form, form; die Farm, farm; das Publikum, the public; and other derivations from the Latin.

There are of course many other nouns of masculine gender, but there are so many exceptions to the rules which could be formed, that it is simpler to follow the practice of learning each of these nouns with its definite article.

Thus, *e.g.*, der Schall, sound; but das Metall, metal; and die Nachtigall, nightingale; der Nebel, fog; but die Nadel, needle; and die Fabel, fable; der Ring, ring; but das Ding, thing; der Magen, stomach; but das Eiſen, iron; der Hafer, oats; but die Mauer, wall; and das Fenſter, window

1. The grammatical and natural gender do not always coincide in German. Thus the diminutives of masculine and feminine nouns are neuter, and are formed by the suffixes ⸗chen or lein: der Vater — das Väterchen (or Väterlein), little father; der Mann — das Männchen (or Männlein), little man; die Mutter — das Mütterchen (or Mütterlein), little mother; die Tochter — das Töchterchen (or Töchterlein), little daughter.

NOTE. das Weib, woman; das Fräulein, young lady; das Mädchen, girl. Die Waiſe, orphan; der Säugling, baby or infant; and das Kind, child; are used for both sexes.

Gender of Adjectives

VIII. The ADJECTIVE agrees (*a*) in gender, number and case with the substantive which it precedes, (*Attributive Adjective*). When used as *Predicate* (*b*), that is to say, after the auxiliary verbs ſein and werden, it remains unaltered.

EXAMPLES: fleißig, diligent; gut, good; ſchlecht, bad; ſchön, beautiful; häßlich, ugly; reich, rich; arm, poor; hoch, high; ſtark, strong; ſchwach, weak; kurz, short; lang, long; rot, red; grün, green; weiß, white; blau, blue; gelb, yellow; ſchwarz, black; grau, grey; braun, brown; kalt, cold; warm, warm; lau, tepid: heiß, hot: naſs, wet; trocken, dry

(*b*) der Knabe iſt fleißig, the boy is diligent;
die Frau iſt fleißig, the woman is diligent;
das Kind iſt fleißig, the child is diligent.

(Examples for (*a*) will follow in chapter dealing with the declension of the adjective.)

The Interrogative

IX. The DIRECT QUESTION is formed by placing the verb with the personal termination at the beginning of the sentence. Thus in the sentence: ich habe geſchlafen, (I have slept); habe is the verb with the personal termination, and the form of question would be: Habe ich geſchlafen?

EXAMPLES:

Ich bin arm,
I am poor,
Bin ich arm?
Am I poor?
Wir ſind reich,
We are rich,
Sind wir reich?
Are we rich?
Die Frau hat ein Kind,
The woman has a child,
Hat die Frau ein Kind?
Has the woman a child?

1. Under no circumstances is the verb thun (to do) to be used in questions, as in English. Thus, Do you speak German? is *never* translated: Thun Sie deutſch ſprechen? but always: Sprechen Sie deutſch? (Speak you German?).

Did you speak German? is always rendered as: Spoke you German? (Sprachen Sie deutſch?).

Conjugations of Verbs

X. The CONJUGATION OF THE VERB is either weak, strong, or mixed. The majority of German verbs take the weak conjugation.

1. The distinguishing feature of the weak and strong conjugations is the formation of the *Imperfect*, the former by suffixes alone, and the latter by change of the stem vowel. The weak verbs *never* modify the stem vowel.
2. Inflections of weak verbs in the Present Tense:

Indicative:

⸗e	ich lob⸗e	I praise.	
⸗eſt or ⸗ſt	du lob(e)⸗ſt	thou praisest.	
⸗et or ⸗t	er lob(e)⸗t	he praises.	
⸗en	wir lob⸗en	we	
⸗et or ⸗t	ihr lob(e)⸗t	you	praise.
⸗en	ſie lob⸗en	they	

Subjunctive:

⸗e	ich lob⸗e	I praise.	
⸗eſt	du lob⸗eſt	thou praisest.	
⸗e	er lob⸗e	he praises.	
⸗en	wir lob⸗en	we	
⸗et	ihr lob⸗et	you	praise
⸗en	ſie lob⸗en	they	

3. The -e of the inflections in the 2*nd* and 3*rd* *pers. sing.* and 2*nd* *pers. plur.* is generally dropped in the *Indicative*, but retained in the *Subjunctive* of verbs with stems ending in -d, -ſt, -t, -th; (red-en, to speak; röſt-en, to roast; läut-en, to ring; erröth-en, to blush; etc.), and wherever its omission would result in harsh or difficult pronounciation, for instance, in the 2*nd* *pers. sing. indic.* of verbs with stems ending in hissing sounds: -ſ, -ſſ, ſch, z; like: ſpeis-en, to dine or eat; haſſ-en, to hate; lauſch-en, to listen; ſchnalz-en, to smack one's tongue; etc. — ſpeiſeſt, haſſeſt, etc.
4. Verbs ending in -eln cast off the e of this suffix in the 1*st* *pers. sing: indic.*, for similar reasons of euphony: handeln, to act, to bargain, ich hand(e)l-e; lächeln, to smile. ich läch(e)l-e. The e is, however, retained in the 2*nd* and 3*rd* *pers. sing.*: du handel-ſt, er lächel-t, etc.

Declension of Pronouns

XI. THE DECLENSION OF THE PERSONAL PRONOUNS. (The numbers 1—4 indicate the four cases.)

	Singular 1st Person		*2nd Person*		*3rd Person*					
1.	ich	I	du	thou	er	he	ſie	she	es	it
2.	meiner (mein)	of me	deiner (dein)	of thee	ſeiner (ſein)	of him	ihrer	of her	ſeiner (ſein)	of it
3.	mir	to me	dir	to thee	ihm	to him	ihr	to her	ihm	to it
4.	mich	me	dich	thee	ihn	him	ſie	her	es	it
	Plural		*Plural*		*Plural (for all 3 genders)*					
1.	wir	we	ihr	you	ſie	they				
2.	unſer	of us	euer	of you	ihrer	of them				
3.	uns	to us	euch	to you	ihnen	to them				
4.	uns	us	euch	you	ſie	them				

The bracketed form of the *2nd pers. sing.*, mein, dein, ſein, is sometimes used in poetry, proverbs, and exalted speech.

EXAMINATION PAPER III.

1. Which German nouns have the masculine gender ?
2. What is the difference between the adjective used as a predicate, and the adjective when it precedes the noun ?
3. What is the distinguishing feature of the weak and strong conjugation ?
4. What is the gender of diminutives ?
5. In what way does the German form of question differ from the English ?
6. Which conjugation (strong, weak, or mixed) is taken by most German verbs ?
7. Do the weak verbs ever modify the stem vowel ?
8. What is the peculiarity of the conjugation of the present tense of verbs ending in -eln ?
9. What is the peculiarity of the conjugation of the present tense of verbs with stems ending in -d, -ſt, ,t and -th ?

EXERCISE 1. Insert in the dotted places the auxiliary verbs haben (to have) and werden (to become, to get), and the articles.

Ich .... Vater und .... Mutter. Du .....
I have a father and a mother. Thou growest

ſtark. Er ... . Lehrer. ... Frau ... .
strong. He has a teacher. The woman has a

Mann. .... Kind .... fleißig. ....
husband. The child becomes diligent. The

Mütter .... Kinder. ... Männer .... Fiſch.
mothers have children. The men have a fish.

Ihr .... Onkel; ſie .... Sohn.
You have a uncle; they have a son.

.... Mädchen ..... ſchön.
The girl becomes (is getting) beautiful.

.... Kinder .... fleißig.
The children become diligent.

EXERCISE 2. Insert the definite article.

.... Bruder .... Mutter iſt... Onkel ... Sohnes.
The brother of the mother is the uncle of the son.

.... Löwe iſt ſtark. .... Berg iſt hoch.
The lion is strong. The mountain is high.

.... Auguſt iſt warm. .... Frühling iſt ſchön.
[The] August is warm. Spring is beautiful.

.... Tage werden kurz. .... Südwind iſt warm.
The days become short. The south wind is warm.

.... Rubin iſt rot, ... Smaragd grün und
The ruby is red, the emerald green, and

.... Diamant weiß. .... Stall iſt trocken.
the diamond white. The stable is dry.

... Hafer iſt naß. .... Metall iſt weiß.
The oats are [is] wet. The metal is white.

..... Säbel iſt ſcharf. ..... Nadel iſt gut.
The sword is sharp. The needle is good.

.... Wurm iſt ſchwach. .... Arm iſt ſtark.
The worm is weak. The arm is strong.

.... Weib iſt .... Mütterchen .... Mädchens.
The woman is the [*dimin.*] mother of the girl.

.... Männlein is .... Vater .... Fräuleins.
The [*dimin.*] man is the father of the young lady.

.... Knabe iſt .... Waiſe.
The boy is an orphan.

.... Säugling iſt .... Mädchen.
The baby is a girl.

EXERCISE 3. Insert the conjugational terminations to the stems of the verbs.

Ich arbeit... fleißig. Der Schüler lern...
I work diligently. The scholar (pupil) learns.

Wir ſchreib... Briefe. Du arbeit... Ihr lob...
We write letters. Thou workest. You praise

die Kinder. Der Lehrer lob... den Schüler.
the children. The teacher praises the pupil.

Sie lieb... die Kinder. Sie lieb... die Kinder;
They love the children. You love the children;

ſie lieb... die Kinder.
she loves the children.

EXERCISE 4. Put the sentences of Exercise 3 into the form of questions.

EXERCISE 5. Translate the following English questions into German without using the German equivalent of the auxiliary verb "to do," and translate the German questions into correct English.

Do you smoke ? Do you love the child ?
Does he work diligently ? Dost thou learn ?
Do they drink ?

Schreibſt du einen Brief? Lobt der Lehrer den Schüler? Lieben die Mütter die Kinder? Liebet ihr den Vater? Rauchen wir? Arbeiten Sie? Arbeiten ſie? Arbeitet ſie?

EXERCISE 6. Insert the corresponding cases of the personal pronouns.

.... ſehe* ....; .... lobſt ....; .... liebt ....
I see thee; thou praisest me; he loves her

und .... liebt ....; .... gab .... und .... gab
and she loves him; she gave him and he gave

.... einen Ring; .... liebe ....; .... ſagt* ....;
her a ring; I love it; he tells me;

.... lob-et ....; .... lob-en ....; .... lieb-en ....;
you praise us; you praise us; we love you;

.... ſag-e ....; .... ſag-e ....
I tell you; I tell thee.

Gedenke* ... ...
Remember [of] me, us, you, her, him, it, them.

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* ſeh-en, to see; ſag-en, to tell; gedenk-en, to remember. Gedenken governs the genitive.

Continued

TRANSPOSITION

Transposing at Sight and on Paper. Changing Accidentals. Reading by Intervals. Score Reading. Transposing Instruments

Continued from page 925

By ALGERNON ROSE

THE art of transposition is not modern. In the days of Greece, Claudius Ptolemy transposed the "Hymn of Nemesis" from the old high pitch of the scale of Alypius a fourth lower. But the Greek system of musical notation was different to ours, although in certain respects analogous, because the modern tone-system has been partly evolved through the old ecclesiastical modes.

Ancient Methods of Transposition. In old missals dated A.D. 1300–1400, transposition from one mode to another was regulated by the distinctive colouring of certain of the notes. Coming to later times, Loulié, a French musician, wrote an ingenious book in 1698 published by Estienne Roger, of Amsterdam. In this the author explains the nature of transposition, and sets forth a method of reducing music into any of the keys denoted, either by the acute or grave signatures, and translating them back again into the original, or radical, keys.

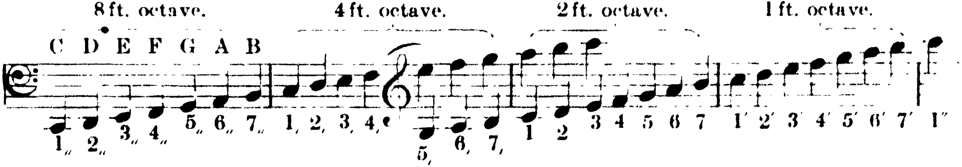
Definition. In music, the word transposition has several meanings, but its usual signification is the rendering of a composition in another key than that in which it is written. This is done either by copying out, singing, or playing a piece by altering the pitch equally from start to finish —whether a semitone, tone, major or minor third, higher or lower, as may be desired. [See THEORY OF MUSIC.]

Transposing on Paper. To alter the key in which a piece is composed by translating it into a different scale is easy enough on paper. Such pen-and-ink exercises should always supplement a student's practical studies. In order to master his instrument, he should practise each study in as many different keys as possible. The most economical way of getting the notation for this is to transpose the exercise on paper.

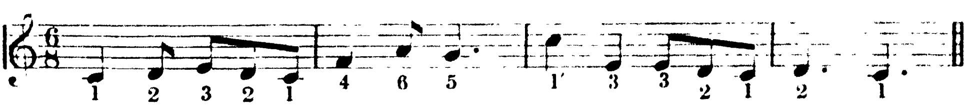
The first point is to find the new tonic, or keynote. After this has been done, alter the key signature accordingly. The rest in a straightforward diatonic composition is a matter of carefully copying out each note at an equal distance above or below the original.

Transposing Melodies. Taking the notes of the three centre octaves of a piano—of which the C just over the lock gives the middle, or first ledger line C beneath the G clef—substitute the numbers 1 to 7 for the letters C to B inclusive. Employ ordinary numerals for the centre, or 2 ft., octave. Add an acute accent to each figure upwards in the next, or 1 ft., octave, two accents for the 6 in. treble octave, and three accents for the 3 in. high treble octave. To discriminate the lower notes, attach a single comma below each number in the 4 ft. octave, two commas to each in the 8 ft. bass octave, and three in the 16 ft. low bass octave.

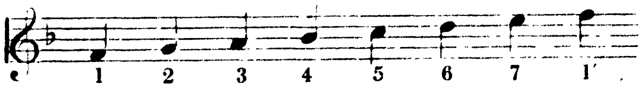
Intervals. Such numbers represent intervals which are alike in all keys although the names, or letters, of the notes alter. Number the scale of C major thus:



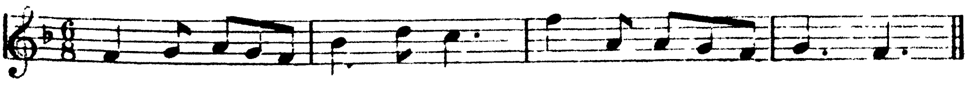
Suppose the melody is as follows:



It is required to be transposed, say, a fourth. A fourth above C is F. F major has one flat—B. Beginning at F, write out and number a similar scale with the one flat signature, thus:



The student, who may know nothing of music, by taking these numbers and writing the notes in their new places, will be able to transpose the melody correctly from C to F, thus:



The first essential, therefore, is to recognise quickly the distance of each note from the first, or tonic, of the scale. By inscribing simple exercises of one octave, and transposing the notes systematically into all the keys, the beginner will soon become accustomed to reckon with the eye the proper position for each note, and will then be able to dispense with the figures.

Obviously, the transposition on paper of any diatonic melody presents no difficulty to the scribe, since all that has to be done is to calculate the higher or lower position needed for each note

Transposing at Sight. It is, however, not infrequently the case that a pianist or organist is required to transpose a piece of music at sight to suit a singer. The task is then more arduous. But it has to be done. For that reason, candidates for examination for the Incorporated Society of Musicians, the Associated Board, the Royal College of Organists, and other institutions, are required to show reasonable ability in this respect.

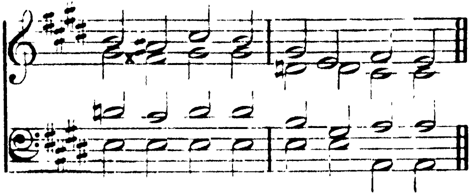
Concert Pitch. When, in 1896, the London Philharmonic Society discarded the high military pitch, and came into tune with the music of the Continent by lowering the British standard to the note represented by A, giving 439 entire vibrations per second when tested at a concert-room temperature of '68 degrees Fahrenheit, the change was widely welcomed by singers, whose voices were unnecessarily strained by the military band pitch. But, owing to the great expense of re-tuning and re-voicing large organs, it happens to-day that when musicians reinforce a church choir with wind instruments at the new pitch, or if the organ has been altered and bandsmen bring in instruments at the old pitch, the organist is forced to transpose at sight a semitone lower or higher, as the case may be.

He cannot, like the guitarist, alter the pitch of his instrument by putting on a capotasto, neither can he adopt the device of the violinist called the scordatura, and thereby deviate from the ordinary tuning as required.

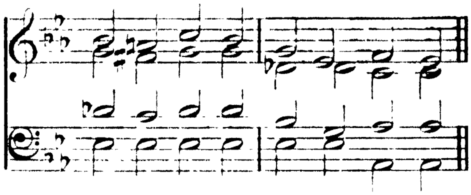
Extreme Keys. Usually, all that is wanted is to transpose a semitone up or down. In this case the task is comparatively easy. Taking C major and A minor as the normal scales of our musical system, all the pianist or organist has to do when required to raise the pitch half a tone is to change mentally the signature to C sharp major or A sharp minor. Should the sounds have to be lowered, the transposer imagines that the signature is C flat major or A flat minor. It may be argued that extreme keys, bristling with sharps or flats, are very difficult. That depends on whether the student has, or has not, taken the trouble to accustom himself to them. He will now perceive, in a way which may not have been before apparent, why it is advantageous to practise as often as possible scales which have many accidentals.

Changing Accidentals. To understand this method of transposition, it is better not to begin with C or A. Take a hymn in the key, say, of E major, like Barnby's "St. Hilda." To transpose it down to E flat major, obliterate from the mind the printed signature of four sharps. In their place think of the three flats B, E, and A. Then play the music as written, except when an accidental occurs. As the key is lowered half a tone, whenever a natural arrives in the music the mind must transform that natural into a flat. When a sharp comes along, imagine that it is a natural. In the same way, a double sharp must convert itself into a single sharp, and a single flat into a double flat. We have only space here to quote the 5th line:

"St. Hilda." BARNBY.



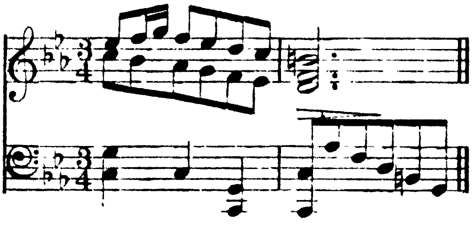
Transposed a half-tone lower.



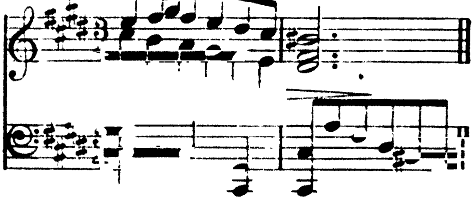
On the other hand, if the hymn chosen is in E flat major, and has to be transposed a semitone upwards, the mental process is reversed.

Obliterate from the mind the signature of the three flats. In their places substitute the four sharps F, C, G, and D. Wherever a natural occurs on the printed page, it must become a sharp. A flat changes into a natural, a sharp into a double sharp, and a double flat dissolves into a single flat.

"St. Matthew." BACH.



Transposed up a half-tone.

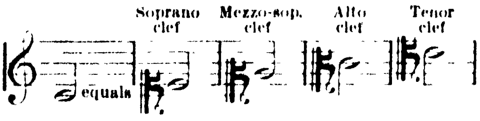


Reading by Intervals. It is when we come to transposition at intervals of a third, fourth, fifth, and so on, higher or lower, that the task of the reader increases in difficulty. On such occasions the player must be either well acquainted with the rules of harmony or familiar with the piece before he attempts to transpose. The eye then reads by intervals rather than by actual notes. Infant prodigies at the piano can go to the instrument and play by ear melodies they have heard with appropriate harmonies. Usually they are capable of playing the tune in any key they fancy. This gift comes naturally to them. It is called "playing by ear." The child cannot analyse the way in which the result is obtained. But the moral of this is that the younger the student happens to be, the better is his chance of becoming a skilful transposer if he gives his mind, while it is yet plastic, to this useful branch of musical study.

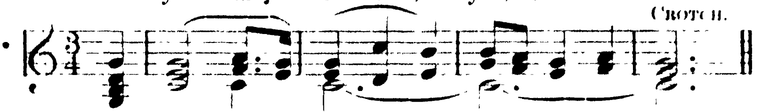
In transposing to a key more than a semitone higher or lower, the player who has studied harmony does not trust to chance. He takes his cue from the lowest note. From that he builds up the superstructure grammatically. To do this requires, with most players, long and constant practice. A privileged minority seems to develop the knack by instinct. With such players, as in the case of that ideal accompanist Mr. Henry Bird, transposition is always made artistically. The best part of the pianoforte is, or should be, its middle register. To transpose a piece a fifth, sixth, or seventh lower than it is written may entirely alter the character of an accompaniment, and cause it to sound lugubrious in a way never intended.

Retaining the Composer's Intention. This is one of the objections musicians have to mechanically transposing keyboards, the main one, of course, being that they cannot take such contrivances about with them like fiddles. By occasionally altering the disposition of the written notes in arpeggios or chords, the accomplished accompanist contrives to enhance the effect of the voice, and communicate the nature of the original composition, thus retaining the intention of the composer. The class of musician most accustomed to transposing at sight is the orchestral player. For him it is less difficult than the pianist. He reads from only one stave, and usually a succession of single notes.

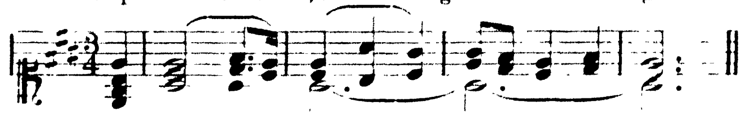
The "C" Clefs. The pianist ordinarily confines his attention to the treble and bass clefs. But the studious instrumentalist who has made himself conversant with the various C clefs is able to use these when transposing at sight, and thus save himself all trouble of calculating intervals. In the days of Purcell these extra clefs were common in vocal music. With the exception of the tenor clef, they are now seldom used. Instead of C being indicated on the first ledger line below the staff, as it is when our G, or treble, clef is used, the soprano clef places that note on the first line, the mezzo-soprano clef causes it to rest on the second line, the alto on the third line, and the tenor on the fourth line, thus:



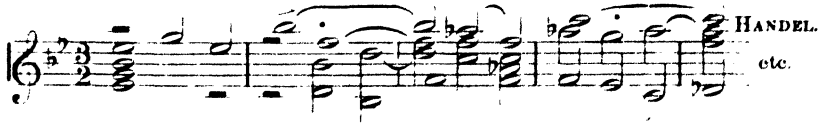
The Soprano Clef. The music transposes itself automatically by substituting the soprano C mentally for the treble G clef, and playing the notes as written, remembering the requisite accidentals for the new signature. Read in this manner, the substituted clef causes the music to sound a third lower or a sixth higher. Thus, if the original is in C major, it is now heard in the key of A major. Therefore, every F, C, and G must become sharp.



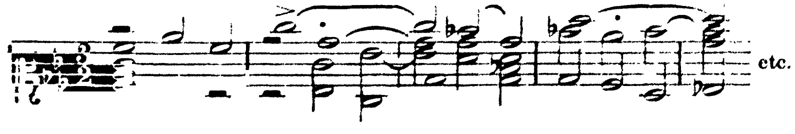
The same notes transposed a third lower, or a sixth higher if "8vo" is imagined above them.



The Mezzo-soprano. When the mezzo-soprano C clef mentally supersedes the G treble clef, and the signature of the new key is borne in mind, the player is able to render the printed notes at once a fifth lower or a fourth higher. Consequently, if the original is in C, the key will now be F, with one flat—B. If in B flat the transposition will be to E flat, thus:

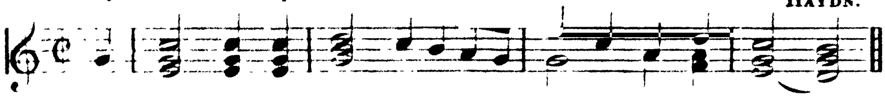


The same notes transposed a fifth lower, or fourth higher if an "8vo" is imagined above them.

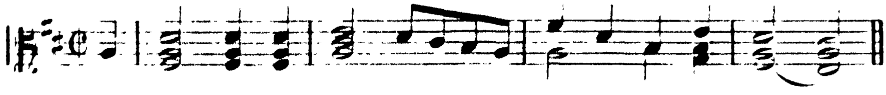


The Alto. Reading in the alto in place of the G clef, the player transposes a seventh lower or a second higher. A piece written in C major, but taken in the alto clef, will thus sound in D major, with two sharps—F and C.

HAYDN.

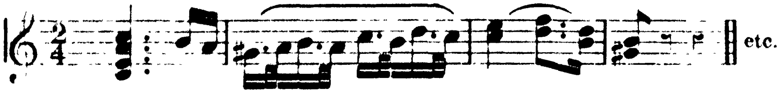


Same notes transposed a seventh lower, or second higher if an "8vo" is imagined above them.

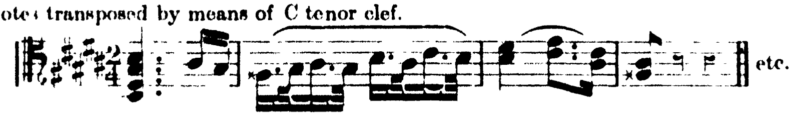


The Tenor. In the same way, the player can transpose music written in the G clef a ninth lower by reading it in the tenor clef, so that a piece in C major played in the tenor clef (giving 2 ft. C on its fourth line) will sound in the key of B, with five sharps—F, C, G, D, and A; in other words—irrespective of octave pitch—a second lower or a seventh higher:

BEETHOVEN.



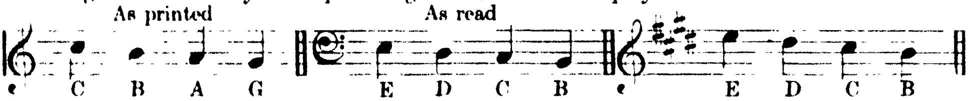
Same notes transposed by means of C tenor clef.



So here we have a ready method of transposition of a third, fifth, seventh, and ninth without the trouble of calculating intervals.

The Bass. But the resources of the instrumentalist are not yet exhausted. If he obliterates the G clef and puts in its place the F, or bass, he lowers the tone a third. But he must then read the sounds a double octave higher than they are written. Supposing the key of the original to be C major, the note sounded will now be in A, with three sharps—F, C, and G.

Having affixed mentally the requisite signature, the notes if played in treble clef would read:



The intelligent student will not lack employment, no matter what instrument he takes up, if he translates systematically the exercises he practises into different keys by means of the various C clefs. When reading the notes with any C clef, the sound can be also transposed, either up or down a semitone, by making mentally a further variation in the signature, in the manner already explained. But this must not be attempted before the student has accustomed himself to reading various exercises in the old vocal clefs and the bass.

Score Reading. The student who neglects to make himself acquainted with transposition will never become proficient in reading an orchestral score. To comprehend an old vocal score where the various C clefs are used, the mental process indicated for translating the sound from the G into the C clefs is, of course, reversed by the beginner, in the same way that an English schoolboy learning French at first slowly translates every French word into its English equivalent before understanding it.

A Full Score. If we take a modern full score, we may find some 30 different parts, ranged one above the other. A non-musician, accustomed to read a single line of letterpress from left to right, regards such notation as hopelessly complicated. Yet it is far superior to his own. It conveys not only the exact rhythm and speed at which every syllable should be read, but also the mental mood in which it must be received. Moreover, musical notation has the gift of brevity. The longest sentence penned can be portrayed vertically in a single sustained chord. If we examine the opening page of a full score, it will be observed that only certain instruments such as the violin, trombones, the oboe and bassoon in C, the harp and organ, play the notes as written. These instruments are called "non-transposing."

Transposing Instruments. On the other hand, the student will observe that the clarionet in A sounds a minor third lower than the printed notes; that the trumpet in E flat expresses itself a minor third higher, and that the horn in D utters its sound a seventh lower. In military scoring there are many such complications. The modern composer, anxious to startle, is, of course, at liberty to avail himself of any and every tone-colour his fancy dictates.

Transposition Concluded

Continued from page 1034

MINIATURE PAINTING

Pastel Work. Miniatures. Choice of the Ivory. The Early Miniature Painters. "Spacing." Framing. Deterioration in Modern Work

By P. G. KONODY

Drawing in Pastel. The nature of the material used for this work—that is to say, of coloured chalks—immediately suggests the limitations of pastel work. Chalk, whether black or coloured, is a *drawing* material, and to use pastel colours in imitation of oil paint is therefore a misapplication of the medium. They should be used for sketching, especially on tinted papers; they should be lightly and daintily handled, and should suggest rather than express. It is impossible to get any degree of transparency into a thick layer of pastel chalk. A sky, for example, thickly smeared over with the lightest blues or greys will invariably appear heavy and leaden. The happiest effects, either in landscape or in portraiture, or, in fact, in any other class of subject, are achieved, if the paper itself supplies the visible ground of the drawing and the chalks are put on in slight, sketchy touches.

What to Avoid. No *pictorial* effects should ever be attempted. Whistler's use of pastel chalks may be quoted as an ideal instance of appropriate treatment. Many of these have been reproduced in excellent facsimile in the "Studio," and in a special portfolio published by the same magazine. Pastel drawing bears about the same relation to painting in oils or water-colours as etching does to mezzotint or line engraving. When the etcher ceases to use his needle in a free, sketchy manner, and makes it serve for the laboured, mechanical interpretation in black and white of a painting, he has overstepped the natural limitations of his medium, and his work ceases to be art; it becomes mere craftsmanship. And so it is with the use of pastel in imitation of oil paint. It lends itself more than any other medium to the rapid expression of an artist's individuality, and for this very reason it is useless to advise the student how to manipulate this material. If he has anything to express, and if he realises the limitations of pastel, and its dainty charm within these limitations, he will soon feel at home in using it.

Though pastel colours are permanent, no reliable method has yet been discovered of fixing them to the paper, and pastel drawings have therefore to be handled with the utmost care lest the brittle chalks should rub off or crumble away. The best way of preserving such drawings is between two sheets of glass. Tinted paper is preferable to white, and ordinary brown packing-paper, not too dark in shade, is an ideal ground for such work. The drawing-paper should be neither very rough nor very smooth, as in both cases the powdery nature of the chalks makes it impossible to get a satisfactory result.

The Story of the Miniature. As conceived by the vast majority of modern workers, miniature painting is a comparatively easy method of using photographic truth and the innate qualities of ivory—its transparency and warm tone—to obtain pleasing results in small portraiture. At the time of the great masters of this art, from Holbein to Cosway and Engleheart, it was the art of painting noble and beautiful portraits of exquisite quality on a very small scale. Their miniatures are small only in size, but grand in conception, like fine life-size portraits. The early miniature painters—Holbein, Cooper, Oliver, Hilliard, and others—worked on parchment and paper, and were, above all, masterly draughtsmen, whose portraits were drawn with wonderful precision, and were full of life and character. Cosway, too, did beautiful drawings on paper, but he recognised the charm of the effects that could be obtained on an ivory basis, and in his admirable work created a delightful convention, graceful and dainty, but rather shallow, which, in the hands of feeble imitators, has proved the ruin of the art.

The student who wishes to take up miniature painting cannot be too emphatically advised not to touch ivory until he is able to draw a good miniature on paper. It is the best and only training that can be recommended, and if he has the solid basis of knowledge and firm draughtsmanship, which can only be thus acquired, he will soon learn the comparatively easy trick of working on ivory, which, of course, requires a different technique. Miniatures on paper are nothing but water-colour drawings on a very small scale, so that no further explanation is here needed.

How to Select the Ivory. In working on ivory, the first consideration is the choice of the material, in which one cannot be too careful. Ivory for this purpose can be bought ready for use at most artists' material dealers. The piece chosen should be as clear as possible—that is to say, one should endeavour to find one free of grain and ribs, especially in the centre, where the face would naturally be placed in the picture. As regards colour, the natural tint—a pale cream—is preferable to the bleached and dead-white ivory, though the coldness of the latter can be counteracted by yellow paper behind the semi-transparent ivory, which produces approximately a natural effect.

A very small, light drawing-board should be used, on which the ivory is fixed by pins. These pins are, of course, not put *through* the ivory, but along the margin, so that the little plaque is held down firmly by the heads of the drawing-pins. Four pins, one at each corner,

By Hilliard

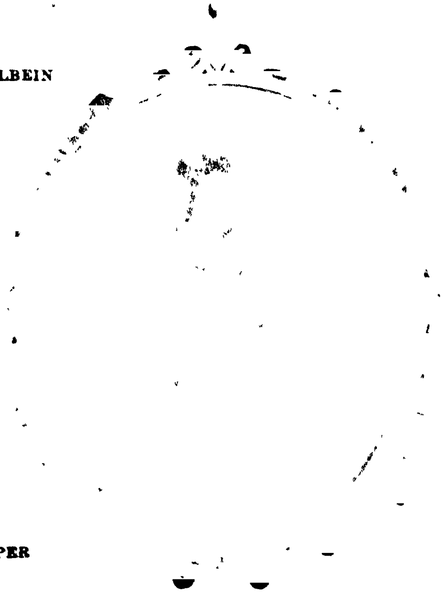
By Oliver

By Hilliard

should be sufficient. A piece of clean paper should be between the board and the ivory, as otherwise the grain and inequalities of the board would show through. If the ivory is not quite firmly fixed to the board, it will curl up directly the wet point of the brush touches it, which would make it impossible to work on.

Before working on the ivory, it is advisable to make a rough sketch of the portrait on paper, so as to get the approximate "spacing" of the picture. Then begin to draw the portrait very carefully with pale water-colour: light red is useful for the face, but, in any case colour which can be ultimately part of the miniature itself should be chosen. Pencil cannot be used, as it will show through any paint laid over it, and, moreover, it makes the ivory black and smudgy, and cannot subsequently be removed. It is better, of course, to keep the colour rather cold at first, and to leave the warmest tints for the very last touches, as the warm colours — such as any of the madders, burnt and raw sienna, and even

By Holbein



By Cooper

EXAMPLES OF MINIATURES OF THE OLD SCHOOL

Photographs by permission of Messrs. Duveen

By Engleheart

By Cosway

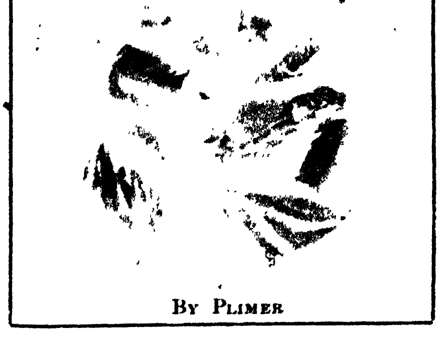
EXAMPLES OF MINIATURES OF THE LATER SCHOOL

Photographs by permission of Messrs. Duveen

By Engleheart

too much yellow ochre—cannot be reduced afterwards by cold tints. They will always show through, whereas the greys can be quickly and easily relieved by the addition of a tint of yellow and brown, which will give a brilliant effect. If grey tints are put on warm shadows, the colour becomes dead and leaden.

Now proceed to build up the portrait gradually, always working over the whole surface, and bringing the *entire head* nearer completion with every sitting. Think only of the modelling, outline, and colour. The stippling necessary for the finish of the miniature will come naturally, for ivory has so slippery and difficult a surface that, however carefully the tones are laid on, there are sure to be some inequalities which can only be removed by stippling. Only when the portrait is finished—that is to say, when the colour has the necessary strength, and when the features are clearly drawn and sufficiently modelled—should stippling be resorted to as a means of sweetening the tones, and giving the velvety texture of skin which is found in the works of masters, and which is needed for work on so small a scale. But a broad style is by no means incompatible with miniature painting.



By Plimer

Modern Miniatures. Almost the worst faults of the modern miniature painter are slovenliness and lack of drawing. The student will do well to avoid modern miniatures altogether. There is practically nothing to be learnt from them. It is a regrettable fact that many of those who call themselves miniature painters have only taken to this form of painting because they have found themselves unable to succeed with any other medium ; to paint a bad miniature is the easiest thing in the world. Study the perfect drawing and strength of the old miniaturists. These and your own model will be all you need to study. Do not work too long at a time, as it is impossible to keep one's eye fresh for such minute work longer than two or three hours at the most.

How to Cut and Prepare the Ivory. An oval shape is usually preferred for portrait miniatures, but the ivory plaques are sold in square pieces. It is, therefore, necessary to cut the finished miniature to the required shape. This is best left to the frame-maker, or to the dealer who supplies the ivory ; for the cutting is a difficult matter, and the first few attempts usually end in the miniature's splitting right across in the direction of the grain.

It is, therefore, best to practise on waste pieces in order to save the material. Very sharp scissors must be used, and it is always better to cut a little outside the actual edge of the picture, as the frame will very slightly overlap the surface. In framing, it is again necessary to have a clear piece of paper behind the painting, and it is usual to back the miniature with several pieces of paper or card, to make the velvet back fit tightly against the ivory.

Continued

Group 13

GEOGRAPHY

8

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SCOTLAND

The Orkneys and Shetlands. The Hebrides. The Highlands. Glenmore. The Lowlands. Scottish Coalfields. The Southern Uplands

By Dr. A. J. HERBERTSON, M.A. and F. D. HERBERTSON, B.A.

EACH region of the British Isles has its own character—inland or maritime, highland or lowland, agricultural, pastoral, or manufacturing, and each must be briefly described.

The Scottish Islands. In the Orkneys and Shetlands we are on the fringe of inhabited Britain, among a people mainly Scandinavian. Both groups number scores of islands, most of which are uninhabited. In the Shetlands, Mainland is the largest island; it is over 50 miles long, but so intersected by the sea that no place is more than four miles inland. Lerwick is the chief town. In all the islands the shores are wild and rocky, and the interior is a bleak, treeless moorland, feeding cattle, sheep, and small ponies. The climate is almost too wet and cool for agriculture, but some barley, oats, and potatoes are grown. Nearly every man is a fisherman, the herring and whale fisheries being very important. In the long winter nights the women knit fine shawls of the soft island wool for export. Life in the Orkneys is very similar to that in the Shetlands. A good deal of barley is grown, from which whisky is made. Pomona is the largest island, and Kirkwall the largest town.

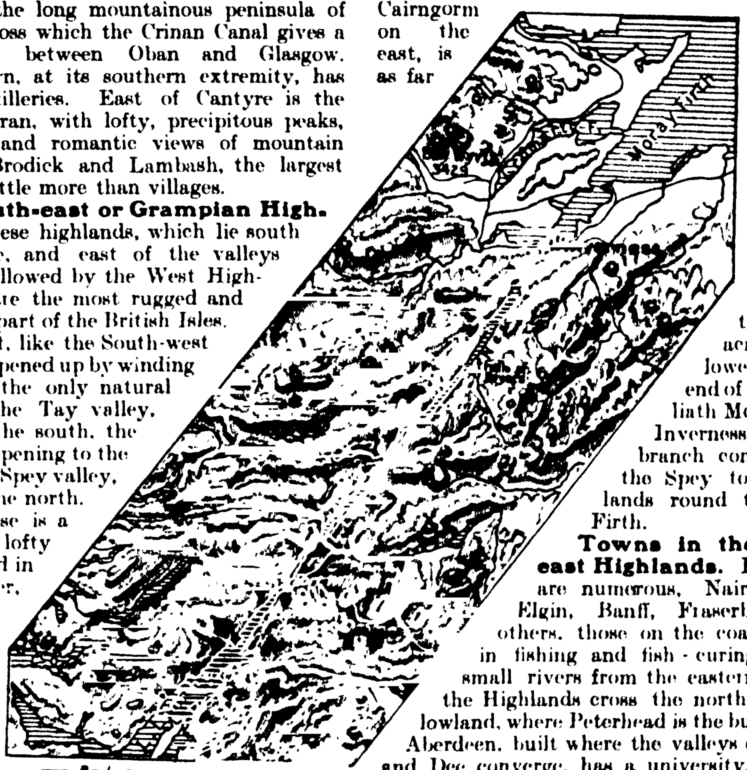
The Hebrides, off the west coast, are divided into the Outer Hebrides, of which the largest is Lewis, and the Inner Hebrides, with Skye in the north, Mull in the centre, Islay in the south, as well as many smaller islands. Surrounded by stormy seas, and shut in by difficult coasts, with fierce currents running between the islands, it is natural that the fisheries, though important, should not be very profitable. The wet climate does not favour agriculture, and much of the interior is poor moorland, only fit for sheep or deer. In summer the beautiful sea and mountain scenery brings many tourists, who add something to the scanty resources of the islanders. Peat is the chief fuel, and oatmeal and fish the staple diet. Simple habits prevail, and cottage industries are still carried on in the long winter nights. The hand-woven Harris tweeds are made in the south of Lewis, in the north of which is Stornoway, the chief town and fishing centre. Portree in Skye, Tobermory in Mull, and Bowmore in Islay are all tourist centres. Iona, with its relics of early Christianity, and Staffa, with Fingal's Cave, both east of Mull, are much visited in summer.

The North-western Highlands. The map indicates the character of this region. Lying far north, where the summers are short and the winters long, and with little land under 1,000 feet above the sea, the conditions of life must ever be severe, and population scanty. In the west, the mountains come down to the sea, which has drowned the lower valleys, forming fiords. These open to wild and lonely glens, often filled by long, narrow lakes, fed by innumerable mountain torrents, whose waters, browned by a peat soil, leap from boulder to boulder in wild beauty. An occasional sheep-farm or shooting lodge is the only sign of life, for this is the home of the sheep and deer, not of men. Strome Ferry, on Loch Carron, is the only important town. In the north-east is the lower tableland of Caithness, whose red sandstones, resembling those of Orkney, are largely quarried. The softer rock and lower elevation allow of some agriculture, but fishing and sheep farming are still the chief occupations. Bare moors, known as deer forests, are numerous, and the salmon fisheries in the streams bring tourists in summer. Towns are more numerous than in the west, and include Thurso, Wick, Dornoch, Dingwall, Tain, and Beauly.

Two railways reach the west coast, one at Mallaig, from Fort William, at the southern end of Glenmore; one at the Kyle of Lochalsh, beyond Strome Ferry, from Inverness at the northern end of Glenmore. This wonderful natural rift, running from Moray Firth to Loch Linnhe and the Firth of Lorne, divides the highlands into two parts. On either side of Glenmore—the Great Valley, or Glen—tower bare mountains, with here and there a glen opening to east or west between hillsides, which in summer are golden with gorse or purple with heather. In the floor of the glen are Lochs Ness, Oich and Lochy. Across the alluvial flats between them canals have been cut converting Glenmore into the Caledonian Canal. At the north end is Inverness; at the south end of Loch Ness is Fort Augustus, in the centre; and at the south end of Loch Lochy is Fort William, behind which are seen the precipitous flanks of huge Ben Nevis (4,400 ft.), the highest point in the British Isles.

The South-west of the Highlands. This region of sea lochs and mountain glens, part of the South-eastern Highlands, has a beauty all its own. It is inhabited only along the shores of the fiords, where fishing villages are numerous. It is, indeed, most accessible by sea, for few roads and no railways are carried up its steep glens. It is busy and prosperous in the short yachting and shooting season, but the winters are long and lonely. After Fort William, the chief town is Oban, further down Loch Linnhe, a centre of yachting and steamer traffic. This district is connected with the south by the picturesque West Highland Railway. The line from Fort William crosses the desolate, boulder-strewn moor of Rannoch to Loch Lomond, which opens a direct route south to Dumbarton and the Clyde. Another line runs from Oban round Loch Awe to Loch Earn and by the river Teith to Callander. The Lower Clyde, below Dumbarton, is a magnificent fiord, from which smaller fiords open to the north. At its mouth is the hilly island of Bute, with Rothesay, on a magnificent bay, commanding one of the finest views in the world. This is the starting place for the famous Kyles of Bute, a chain of sounds opening to Loch Fyne, at the head of which is Inverary. The western wall of Loch Fyne is formed by the long mountainous peninsula of Cantyre, across which the Crinan Canal gives a short route between Oban and Glasgow. Campbelltown, at its southern extremity, has famous distilleries. East of Cantyre is the island of Arran, with lofty, precipitous peaks, wild glens, and romantic views of mountain and sea. Brodick and Lambash, the largest towns, are little more than villages.

The South-east or Grampian Highlands. These highlands, which lie south of Glenmore, and east of the valleys and lakes followed by the West Highland line, are the most rugged and inaccessible part of the British Isles. They are not, like the South-west Highlands, opened up by winding fiords, and the only natural routes are the Tay valley, opening to the south, the Dee valley, opening to the east, and the Spey valley, opening to the north. Between these is a bleak and lofty region, buried in snow in winter, across which the railways and roads are carried with great difficulty. Much of it consists of grouse moors and deer forests. Sheep farms are scattered among the hill pastures of the lower valleys, and some agriculture is possible where these open to the lowlands. Towns are found only at the valley mouths.



70. GLENMORE AND THE CALEDONIAN CANAL

The southern margin of this great highland area, which descends steeply to the plain and from Perth looks like a mountain range, is called the Grampian Mountains. In reality it is only the edge of a great plateau which it is convenient to call the Grampian Highlands. All the routes from the north converge on Perth on the Tay, and Stirling on the Forth, both on the margin of the plain. From the latter a route goes to Callander, at the mouth of a valley leading to the Trossachs Pass, Loch Katrine, and Loch Lomond, one of the finest tours in the Highlands. Crieff, similarly situated further north, commands similar routes. Perth, on the Tay, at the end of the Sidlaws, commands routes in all directions, and is the key of the Highlands. The main route to the north follows the Tay to Dunkeld, situated like Callander and Crieff. After receiving a branch from the west, by Loch Tay, it traverses the wild ravine of the Garry by the famous pass of Killiecrankie, and crosses the divide to the Spey valley at a height of 1,500 feet. This natural route between the Monadhliath Mountains on the north-west, and the Lochnagar and Cairngorm Mountains on the south-east, is followed as far as Aviemore, through wild and desolate scenery. After Aviemore the main line strikes away from the Spey across the lower eastern end of the Monadliath Mountains to Inverness, while a branch continues by the Spey to the lowlands round the Moray Firth.

Towns in the South-east Highlands. Here towns are numerous, Nairn, Forres, Elgin, Banff, Fraserburgh, and others, those on the coast engaged in fishing and fish-curing. Many small rivers from the eastern slopes of the Highlands cross the north Aberdeen lowland, where Peterhead is the busiest town. Aberdeen, built where the valleys of the Don and Dee converge, has a university, and is a fishing and fish-curing centre, as well as a busy port, shipping grey granite to the south. A line follows the Dee valley to Ballater, near Balmoral, amid the magnificent scenery of the inaccessible Cairngorm and Lochnagar Mountains, the former separating it from the Spey valley. Many valleys, with towns at their mouths, open to the lowlands of Forfar, which form part of the Midland Plain. Montrose and Arbroath on the coast, and Forfar inland, are the largest towns north of the Sidlaws.

The Midland Plain, or Lowlands. At the base of the southern escarpment of the Grampian Highlands extends Strathmore, a broad stretch of old red sandstone, with a deep and fertile soil. It is bounded to the south by a broken line of heights, known under various names, between which the rivers reach the sea. The Tay and Earn reach the Firth of Tay between the Sidlaw Hills of Forfar and the Ochil Hills of Fife. South of the former is the fertile Carse of Gowrie, with Dundee, manufacturing jute and marmalade, as its chief town. Here the Tay estuary is bridged. The Forth, which rises near Loch Lomond, reaches the Firth of Forth, between the Ochils and the Campsie Hills. Stirling, with its towering castle rock, the lava plug which once filled the vent of a long-perished volcano, guards this important gap, and here the river forms its famous links or windings. The Clyde, from the Southern Uplands, with fine falls where it enters the lowlands, reaches the western sea between the Campsies and the Renfrew Heights.

The Scottish Coalfields. South of these heights, which divide the Midland Plain into two parts, are the Scottish coalfields [**69**]. The Ayrshire field, which lies west of the Renfrew Heights, and is consequently isolated except by sea, ships much of its output from Troon and other ports to the manufacturing towns of the opposite coast of Ireland. Kilmarnock, manufacturing woollens, is the chief town of the Ayrshire field. The central, or Forth and Clyde field, extends up the Clyde as far south as Lanark, and as far east as the Forth estuary. Glasgow, built like many other prosperous cities, at the lowest point where a navigable river can be bridged, is the centre of one of the busiest industrial districts in the world. It has immense shipbuilding and engineering works, chemical and other manufactures, and an enormous transatlantic trade. Both banks of the Clyde as far as Greenock are lined with busy towns similarly engaged—Port Glasgow, Greenock, Dumbarton, and others. Of the inland towns, Coatbridge and Airdrie have mining and iron industries, and Paisley manufactures into thread the cotton brought across the Atlantic to Glasgow. The eastern part of the coalfield, with fewer facilities for obtaining raw material by sea, is less busy. Stirling makes tartans, carpets, and other woollens, and Falkirk has collieries, ironworks, and chemical manufactures. The smaller coalfields of Fife and Midlothian are on opposite sides of the Forth estuary. On the former, Burntisland and Kirkcaldy ship coal, Dunfermline manufactures linens, and Kirkcaldy linoleum. The coast is ringed with fishing villages from Inverkeithing to St. Andrews, an ancient ecclesiastical city and university. On the Midlothian coalfield the chief town is Edinburgh, the capital. It is built where the Pentland Hills approach the sea, round a castle-crowned volcanic crag like that of Stirling. There is no road to the north till Edinburgh is reached, and it also guards the routes south into England and west to the Clyde. It has a famous university and medical school. Among its industries paper-making, printing, and brewing are important. Its port is Leith. Above Edinburgh is the great Forth Bridge across the estuary. In the neighbourhood of Edinburgh are collieries and oil shale works, and many paper-mills, worked by the streams coming down from the Pentlands. Fishing villages dot the southern shore of the estuary. Dunbar, at the base of the Lammermuirs, controls the route from England to Scotland round their eastern base.

The Southern Uplands. A line drawn from Dunbar to Girvan, on the Ayrshire coast, marks the northern limit of rocks older than those of the plain, but younger than those of the northern highlands. These form the Southern Uplands. The scenery is less picturesque than that of the highlands. Instead of bare, rocky peaks and precipices, the hills have rounded forms, and soil enough for coarse pastures, bare rock being seldom seen. The four river valleys, of the Clyde, Nith, Annan, and Tweed, must be noticed. That of the Clyde has already been described. The Nith valley, at the mouth of which is Dumfries, with woollen, iron, and leather manufactures, forms one of the main routes between Carlisle and Glasgow. West of the Nith the hills are wilder and the valleys more fertile. Kircudbrightshire is famous for its heather honey. Salmon fisheries are important in the Solway Firth. Sheep and cattle are kept throughout this region, the Galloway cattle being a famous dairy breed. East of the Nith is the Annan, giving a route to the Clyde valley. The railway crosses the divide at Beattock, in a sheep-farming district, with a great annual sale of Cheviot rams. The height at Beattock is nearly 1,000 ft., and the surrounding hills rise to 2,500 ft. East of the Annan route passes lead to Selkirk and the Tweed valley, which widens in the east to a considerable lowland. Its tributaries—Gala, Yarrow, Ettrick, Teviot, and others—drain a high, bleak region occupied by scattered sheep farms. The wool is manufactured in small towns in the valleys below—Peebles, Innerleithen, Galashiels, Selkirk, Hawick, and others—all of which are important market towns. Ruined abbeys, of which Melrose on the Tweed is the most famous, show how long this district has been prosperous, and how disastrous were the interminable English wars. Many old keeps and border castles tell the same tale. On the lower Tweed are Kelso, the centre of a rich agricultural district, and Berwick, on the English border. The route from Carlisle to Edinburgh crosses the Southern Uplands by the Liddel, Tweed, Gala, and Esk valleys. That from Berwick skirts their eastern base.

Continued

MUNICIPAL SERVICE
continued from
page 980

THE MUNICIPAL TREASURER

The Duties and Salaries of the Finance Department of Municipal Authorities: Training, Qualifications, and Examinations

By ERNEST A. CARR

THE financial staff of a local authority is less liberally remunerated, on the whole, than that of the town-clerk—the branch we last considered. The explanation, doubtless, is that many subordinate positions in the accounts department are ordinary clerical appointments, whilst the town-clerk's staff requires special training, only an expert being able to perform satisfactorily the duties of a committee or election clerk. Leading financial positions, however, as we shall see, need quite distinctive knowledge and abilities, and are correspondingly well paid.

The Head of the Finance Staff. There is a good deal of diversity of practice as to the title and duties of the head of the finance staff. To quote a distinguished authority, who is himself holding such a post in a prominent county borough, "The chief financial officer of a corporation is styled either Comptroller, Treasurer, or Accountant, the duties of each being of a somewhat similar nature. The position of treasurer is, however, the statutory one, and the majority of corporations are now appointing their leading financial officer in that capacity." In many instances the staff includes both treasurer and accountant, the first holding the senior rank. In some municipalities the two offices are united in a single official; whilst others, again, place the control of their finance department under the borough accountant, and employ a member of a banking firm or the manager of a bank as their nominal treasurer.

Whatever his title, the chief of the financial and accounts branch holds a very responsible office. He is in general charge of the revenues and disbursements of his authority, such large sums passing through his hands that security to the extent of £5,000 or £10,000 is usually required of him. As expert adviser to the council on the financial side of their many operations he has an anxious duty to perform. Not only is he consulted as to the conduct of such matters as raising and extinguishing loans, issuing stock, and fixing terms and rates of interest; the soundness or otherwise of important "municipal trading" schemes, and the proportion of expense which these undertakings should bear, are among the grave questions on which his opinion is of weight. He must further be familiar with the complex system on which municipal accounts, as a whole, are kept, and the bookkeeping methods best adapted to the special needs of trading and other departments. These qualifications can only be acquired by a wide experience of municipal finance in all its branches.

As already pointed out, no absolute distinction can be drawn between the treasurer and the accountant; but where both offices are separately held under the same local authority, the treasurer's concern is mainly with finance and securities, the accountant's with bookkeeping and office checks on expenditure. In these circumstances the former official holds the more distinctly professional appointment; otherwise, the requirements for either position are practically identical, and we may conveniently defer the discussion of their qualifications in order to deal with both together.

The Influence of Municipal Trading. We have seen, in considering electrical and gas engineering and other appointments, that the last decade or so has witnessed an astounding development in the commercial or "trading" activities of local authorities. During that period the revenues derived from public baths and wash-houses, tramways, and the supply of municipal electric light, gas, and water, have increased by leaps and bounds; and there appears to be every prospect of a continued increase for many years to come. The bearing of this development on the finance and accounts staff is too direct to be overlooked. In the words of the expert already cited, "The very large commercial undertakings which are now being carried on by municipalities throughout the country have, during the last few years, materially increased the responsibilities of the finance department, and the importance of its work becomes more and more manifest from year to year." The growth of a department involves a greater number of highly paid offices in it, and thus affords increased scope for able members of the staff.

Treasurers' Salaries. This fact is instanced by the case of the London County Council's chief financial officer, the Comptroller. So greatly has the work of his office increased during the past six years that his salary has advanced in that time from £1,150 to £2,000 a year. The latter is an exceptionally high figure, of course, though it is surpassed in at least one instance. The Chamberlain to the City Corporation, who acts as its treasurer and banker, receives £2,500 a year, rising to £3,000. It should be added that he is an exceptionally able financier, having gained invaluable experience by many years' partnership in a great banking firm. Under less distinguished authorities the income of county and borough treasurers varies considerably, ranging from £500 to £1,600 a year, according to the size of the local body they serve and the importance of the works it controls. Deputy treasurerships are remunerated at about one-half or three-fifths of the salaries attaching to the principal posts. The treasurer to the Manchester

Corporation is paid £1,000 a year, and his deputy £500. On the other hand, the treasurership of a minor county was recently advertised at as small a stipend as £250 yearly, which is probably the low-water mark for an office of that class.

Municipal Accountancy. Where the accountant's functions are distinct from those of the treasurer, they may be summarised as comprising the direct charge of the accounts staff, and a general supervision over the bookkeeping in every other department, so as to safeguard the local authority from losses through carelessness or fraud and to facilitate the periodical inspection of the accounts by the Local Government Board auditor. It is the accountant's duty also to control the collection of moneys, and to frame from the various departmental accounts those elaborate financial statements which are necessary to disclose the position of the county or borough as a whole. The work thus briefly indicated is more complex than anyone who has not explored the mazes of Local Government accounts would be disposed to believe. Its proper performance needs something like a gift for figures, as well as a close familiarity with municipal accounting methods, and inexhaustible patience and alertness.

Owing chiefly to the difference of duties already pointed out, accountancy posts, as a class, are less liberally repaid than treasurerships. They range in value from £250 to £1,000 a year, the latter figure being rarely exceeded. Further details are afforded by the following list of actual appointments of both chief and assistant rank :

Accountants :

Northumberland, £800.
City (accountant auditor), £625.
Nottingham County, £350.
Manchester, £300 and £500.
Holborn, £350.
Wandsworth, £330.
Leyton, £300, rising by £25 annually to £450.
Acton, £250, rising by £20 annually to £350.
Longton, £250.

Assistants and Deputies :

York, N. Riding, £250, rising by £10 annually to £450.
London Water Board, £255, rising by £15 annually to £300.
Manchester, £215.
Holborn and Hull, £180 to about £250 each.
Willesden (accountant's clerk), £150 to £200.

Training and Qualifications. Candidates for county or borough treasurerships are generally required to have qualified as professional accountants, and to be thoroughly versed in municipal accounts and finance, as well as accustomed to control a staff of clerks. For the municipal accountant the same conditions apply, except that in his case a professional diploma is not always insisted upon, vacancies being filled by the promotion of experienced and deserving assistants or accountants' clerks at least as often as they are advertised or reserved for "admitted" men.

The shortest and surest route to a principal position of either grade is to enter as an articled clerk the office of a borough treasurer or accountant who is a Fellow either of the Institute of Chartered Accountants or of the Society of Accountants and Auditors. These are the two general accountancy bodies whose diplomas carry most weight within the municipal world as well as without. Their examinations will be found fully discussed in the CLERKSHIP AND ACCOUNTANCY course, and need not occupy us here.

In this way the student, whilst gaining valuable experience in the practical side of municipal accounting, can prepare for the examinations admitting to the Associateship, and ultimately to the Fellowship, of one of the two institutions named.

On the expiry of his articles he may look with some confidence for an assistantship, and later for a principal appointment. Such a direct road to promotion should on no account be neglected by the fortunate youth to whom a moderate premium and a term of service without a salary present no insuperable obstacle.

On the other hand, the same advancement is within reach of a member of the clerical rank and file who has neither means nor influence to smooth his path, and this fact constitutes the great counter-advantage of the finance branch as compared with more highly paid departments. The post of borough engineer, medical officer, or surveyor, for instance, is almost out of reach of those who are not specially and expensively trained from the start ; but there is no reason why any aspirant for a leading financial post should not—with good abilities, a fair general education, and an aptitude for figures—attain his ambition whilst supporting himself throughout.

One Way of Success. It will be worth while to consider shortly the steps by which a clever lad may pursue from small beginnings such a career as has been indicated. An early start is perhaps the foremost essential for success under these conditions.

Years of practical experience are needed to master the complexities of the many branches of municipal accounting; and local authorities, finding that their best finance officials are those who have been trained to the work from their youth, are reluctant, as a rule, to appoint untrained clerks to these duties after the age of 25 at the latest.

The ambitious youngster will probably gain his footing on the first rung of the ladder of promotion between the ages of 15 and 18 by a position as office youth or junior clerk on the borough treasurer's or accountant's staff. Here he must take every opportunity that arises to master the details of account-keeping, supplementing this practical training by evening classes in bookkeeping, banking, and commercial subjects. In this way he will be qualified for the post of office clerk or junior bookkeeper when a suitable vacancy arises; and after a few years' further experience in that capacity, he should be ripe for promotion—either in the same office or by transfer—to the grade of chief bookkeeper or accounts clerk.

Meantime, it will be advisable for the budding accountant to direct his studies towards obtaining a recognised qualification. We have seen that this is not an indispensable step, but, on the other hand, it offers no colossal difficulties, and, in view of the great value of a professional accountancy diploma when competing for a leading appointment, even the hardest-worked accounts clerk should not neglect it for any but the gravest reasons.

Of the two accountancy associations already mentioned, the Institute of Chartered Accountants admits to its examinations only those students who have served at least three years' articles to a member. For such a self-dependent youth as we have in view, this is an absolutely prohibitive condition, unless his office chief should be himself a chartered accountant, and would grant him his articles on exceptionally favourable terms.

The Society of Accountants and Auditors, however, accepts candidates, other than articled clerks, who have served a specified term of years (six for the intermediate, and nine for the final examination) as clerk to a municipal or other public accountant. The official who is resolutely seeking a professional status may, therefore, find it expedient to take this Society's final examination as soon as possible after reaching the minimum age of 25. He must then wait for promotion to a principal clerkship before he is eligible for the Associateship or Fellowship (A.S.A.A. or F.S.A.A.).

There cannot be two opinions as to the value of this qualification for municipal work. The Secretary of the Society of Accountants and Auditors states that "the post of borough treasurer or accountant to the large majority of the boroughs throughout the country is held by members of this society, the diploma of which carries a great deal of weight in any competition for such an appointment." A reference to the lists of municipal officials amply confirms this claim.

The I.I.M.T.A. There exists, however, for the benefit of municipal officers alone, a somewhat similar society, whose examinations are of especial value, since they are directed to the particular branches of accountancy with which such officials are concerned. This is the Incorporated Institute of Municipal Treasurers and Accountants.

Membership of this body is widely recognised as a proof of efficiency, many local authorities, when advertising a vacancy for a treasurer or accountant, accepting that qualification equally with the F.C.A. or F.S.A.A. diploma. The young student of local government accountancy will, therefore, probably be attracted to an I.I.M.T.A. certificate in preference to those of the other two bodies named. The examination subjects, fees, and other particulars, are set out in the accompanyng schedule. Examinations, both preliminary and final, are held yearly. The centres are determined after all applications are received, but always include London and one Northern town, at least. The scope of these tests is thus defined by the regulations of the Institute:

"The preliminary examination is designed to ascertain that candidates have a practical elementary acquaintance with the business of the finance department of a municipal corporation or kindred authority.

"The final examination is of an exhaustive character, and is designed to test the knowledge of candidates in the whole range of municipal finances and the law relating thereto."

Having attained this, or an equivalent certificate, the former office youth should find himself in the position of chief finance or audit clerk, or assistant accountant, and is fully qualified for an accountancy proper. If he is fortunate, as well as able, he need not have long to wait.

Age Limits. Many chief accountancy positions are held by young men of less than 30. One such post in a busy London borough, at a commencing salary of £350 a year, was lately won by a public accountant of 31; and that at Acton (shown in our list) was restricted to candidates between 28 and 35 years of age. More usually, however, the upper limit is extended to 40 or beyond.

The post of professional auditor, it may be mentioned in passing, is generally held by an accountancy firm in private practice, who provide their own staff of clerks for the audit, and are paid by fees varying from a hundred guineas to nearly ten times that sum.

Rate Collector. For the office of rate collector, no particular qualification is prescribed. The only essentials are integrity, exact bookkeeping, and a general knowledge of the way in which rates are made and recovered. Applicants are not restricted to any one department, and, indeed, are sometimes appointed without previous municipal experience of any kind. The best training, however, is afforded by a clerkship on the rating staff, and from this class the ranks of the collectors are largely recruited. These officers must reside within the district for which they are appointed, and must provide an office and safe. They are usually required to undergo a medical examination before appointment, and to give security for their honesty. Their duties are monotonous, and occasionally distasteful, but considering that no special knowledge or training is needed for the post, they are well paid. The method of remuneration varies; sometimes it is a fixed, and at others a progressive stipend, whilst the income of some collectors varies with the number of assessments on which the rates are recovered. For the smaller districts, £150 to £200 is the usual salary, and for the larger areas £250 to £350, and sometimes £400. The City Corporation pays its chief collector £500 a year, and this is sometimes exceeded, a suburban official having lately refused an offer of precisely that fixed salary in lieu of the percentage he at present receives on all sums collected. But although the rate collector is well remunerated, he has rarely any prospects of further advancement. "Once a collector, always a collector," is an axiom of the service.

Continued

MUNICIPAL TREASURERS AND ACCOUNTANTS

Examining Body, Time, Grade, Place of Examination.	SUBJECTS OF EXAMINATION.	Fees and Age Limits.
PRELIMINARY. INSTITUTE OF MUNICIPAL TREASURERS AND ACCOUNTANTS (INCORPORATED).	1. **Accountancy:** Bookkeeping and accounts of local authorities. Local authority finance: auditing (rate collection, tolls, etc.). Arithmetic and algebra. 2. **Law:** General principles affecting municipal treasurers and accountants, including statute and common law, real and personal property: mortgages, deeds, agreements, etc., contracts, local rates, duties of overseers, borrowing and rating under certain statutes **Note.**—Candidates must have served three years in finance department of municipal or kindred authority. Successful candidates become student members of the Institute.	£1 1s. See note.
FINAL. Each June at two (or more) centres—*viz.*, London and in North of England.	1. **Accountancy:** Bookkeeping and accounts of local authorities, including material and stores, loans, sinking funds, depreciation and reserve funds, etc., trading undertakings, education, abstracts and balance-sheets. 2. **Local Authority Finance:** Estimates for rates, assessment and rating, capital expenditure, revenue and income, and expenditure, borrowing powers, income tax. 3. **Auditing:** Audit and check of accounts in finance and other departments. 4. **Law:** Municipal Corporations Act, Public Health Acts, Local Government Acts, etc. Duties of overseers, making and enforcing rates, audit of accounts (*a*) audited by Local Government Board auditor; (*b*) not so audited; mortgages, deeds, agreements, etc. **Note.**—Candidates must be Associates of the Institute, or of the I.C.A. or S.A.A., or Student Members of two years' standing, or, if they have served five years in finance department, of one year's standing.	£2 2s. See note.

MEN CLERKSHIPS, LONDON COUNTY COUNCIL

Examining Body, Time and Place of Examination.	SUBJECTS OF EXAMINATION. PART I. Candidates holding certain matriculation or other certificates are exempt from this test. PART II. Shorthand also may be taken as a non-competitive, but useful subject [see Letterpress].	Fees and Age Limits.
THE LONDON COUNTY COUNCIL, Spring Gardens, S.W. When requisite, usually two or three times yearly: Part I. at several London centres, Part II. at one such centre.	**Part I. Preliminary** (Two days). 1. Handwriting } marked from papers 3, 5, and 6. 2. Orthography } 3. English Composition (Essay writing). 4. Arithmetic: Fractions, decimals, cube root and mensuration. 5. English History, including a special period. 6. Geography, including the United Kingdom and another special section. 7. Euclid, Books I.-IV., and VI., or equivalent geometry. 8. Algebra, to binomial theorem. 9. Plane Trigonometry (excluding analytical): solution of triangles. **Note.** All subjects are compulsory. Special importance is attached to 3 and 4.	10s. 18 to 23 years.
	Part II. Competitive (Six days). 1. General Knowledge (*compulsory*). *Any four of the following may also be taken* 2. English Language and Literature: including essay and special books. 3. Pure Mathematics: (i.) higher algebra, (ii.) higher trigonometry and geometry, differential and integral calculus. 4. Applied Mathematics: including analytical statics, particle dynamics, and hydrostatics. 5. and 6. Modern Languages (two): Translation from and into, accidence, and pronunciation. 7. Latin: Translation from and into, accidence and syntax. 8. English History, including a special period. 9. Economics: theory and history, policy of tariffs, etc. 10. Outlines of Local Government: functions of authorities, rates and taxes. 11. Elements of English Law: constitutional law, contracts, evidence, etc. 12. Experimental Mechanics: construction and use of apparatus, proofs of mechanical principles, etc. 13. Experimental Physics: laws and phenomena, laboratory methods for simple physical measurements. 14. Chemistry, practical and theoretical, including metallic chlorides, nitrates and sulphates, compounds of iron, sodium and potassium, etc. 15. Bookkeeping and Accountancy, including nature and use of office books, principles of double entry, etc. **Note.** In subjects 1, 2, 5, 6, 12–14, the examination is both written and oral. Practical Knowledge of experimental methods is essential in 13 and 14.	10s. 18 to 23 years.

Full particulars, with a detailed syllabus of subjects, can be obtained from the Clerk of the London County Council, Spring Gardens, S.W. The papers set at past contests are supplied by Messrs. P. S. King and Son, 2, Great Smith Street, Westminster, S.W., at 5½d. per set, post free. Approaching examinations are advertised in the leading London newspapers

THE SEDIMENTARY ROCKS

How Sedimentary Rocks were Produced. Sandy and Clayey Rocks. Limestones. Coal. Volcanic Rocks. Metamorphism. Schists

Group 14
GEOLOGY
5

Continued from page 1009

By W. E. GARRETT FISHER

have already seen quite clearly that the igneous rocks are the oldest constituents of the earth's crust. Since the earth once existed in the form of a nebula, or fiery cloud of warring atoms, and cooled by successive stages into the planet which we now inhabit, it is perfectly evident that there was a time when its surface consisted solely of igneous rocks—granites and basalts, and their allied families. But at present the most casual observation tells us that this is no longer the case.

Sedimentary Rocks. The surface of the earth is mainly covered with what we call *soil*, the product of disintegration of hard rocks by atmospheric and other agencies. This layer supports all life on the earth, because it brings forth vegetation, and so feeds animals, and, directly or indirectly, mankind. Underneath this we find a *subsoil* of very varying formation, if we examine it by driving a shaft or a borehole, or by studying the sections of the crust which are made by natural cliffs, as on the sea-coast, or by artificial cuttings for a railway line or a quarry. Sometimes the soil lies on the top of what we can recognise as an igneous rock; some of the most productive of Italian vineyards, for instance, are separated by only a thin layer of rich soil from the lava of a volcano. But more frequently the subsoil proves to be different from any of the igneous rocks that we have studied. It is non-crystalline, is arranged in definite layers or *strata*, and contains fossils, or relics of vanished forms of life. By all three characteristics, or by the two first, which are often present without the third, we then decide that this subsoil is not an igneous but a *sedimentary* rock. In other words, it must be a product of later growth than the igneous rocks; for as the whole of the crust was once igneous, the sedimentary rocks must have been derived from these, whence they are sometimes called *derivative* or *secondary* rocks. In later chapters we shall have to study the processes by which the sedimentary rocks have been produced. First, however, we must make acquaintance with their various characteristics and the families into which they may be divided.

How Sedimentary Rocks were Produced. The classification of the sedimentary rocks is much simpler than that of the igneous rocks. They are far less varied and complicated in structure than those from which they are derived, partly because the natural agencies which have broken down the igneous rocks into these secondary products are less powerful and consequently less sweeping in operation than the agencies of heat, chemical action, and pressure which have produced the igneous rocks. The latter were compounded in the great laboratory of Nature, in the molten interior of the planet; the former came into existence on the earth's surface under the milder influence of rain, sea and rivers, frost and ice, wind and weather. It is quite natural that their forms should be less complex and their origin easier to comprehend. We shall see later how they were produced. It is enough to say here that they have all been formed of fragments broken from igneous rocks, and deposited in layers. This was generally due to the action of water, in which they were mechanically *suspended*—like the mud in a brook that runs dark and turbid after heavy rain—or chemically *dissolved*, like the salt in the sea. They are, in fact, the *detritus* of the earlier world, the broken-down relics of the primitive igneous rocks. A possible way of classifying them would be according to the nature of the agency which broke down the older rocks and rearranged them, as follows:

(*a*) *Æolian* rocks, produced by the action of wind, like the vast beds of loess which form some of the most fertile tracts of China.

(*b*) *Aqueous* rocks, formed by the agency of water. These form much the largest group, and may be subdivided, according to whether the fragments have been deposited from a condition of mechanical suspension in the water—sandstone and shale—or have been crystallised from a solution—rock salt and crystalline limestone.

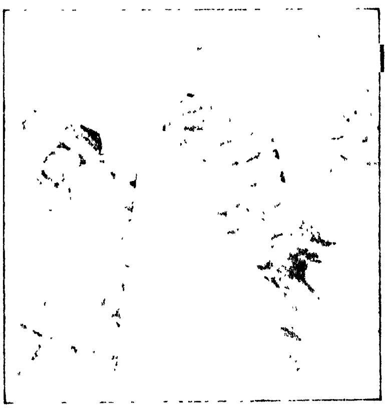
(*c*) *Organic* rocks, formed by the action of life, like coral, chalk, and many limestones.

(*d*) *Volcanic* rocks, or *Tuffs*, which result from the breaking up of lavas and their ejection in fragments by volcanic eruptions.

Classification of Sedimentary Rocks. This classification deserves notice, as it gives a preliminary idea of the methods by which the sedimentary rocks were formed. But it is not a very good one, as the examples named will show. Are we to classify chalk, for instance, as an aqueous or an organic rock? It was all laid down by the water of the sea, in which its constituents were once floating. But it is also mainly composed of the remains of innumerable tiny creatures, which formed the calcium carbonate of the sea water into shells and skeletons. Probably the most convenient classification is that which depends on the chemical composition of the rocks. We find by investigation that the sedimentary rocks are far less complicated in this respect than their igneous ancestors. The great majority of them are composed mainly of one of four minerals—*sand, clay, lime*, or *carbon*. According to the prevalence of one or other of these substances, we may divide the sedimentary rocks into four great families: the *arenaceous* or sandy, *argillaceous* or clayey, *calcareous* or limy, and *carbonaceous* or coaly rocks. A fifth class is necessary, indeed, to contain the few sedimentary rocks which refuse to fall into one or other of these families. But that only shows that Nature declines, here as elsewhere, to work according to the strict logical distinctions of the theorist.

A short account of the chief sedimentary rocks with which the geologist has to familiarise himself may now be given. It should be supplemented by reading one of the fuller text-books, and by examination of actual specimens in a museum and in the field.

Arenaceous, or Sandy, Rocks. These are composed mainly of *sand*, which is simply an aggregate of tiny fragments of quartz—pure silica—more or less rounded, and not bound together by any cement. We are familiar with it on the sea-shore, on the margins of lakes and rivers, and by hearsay, as the soil of vast deserts in drier parts of the world. This sand is the débris of quartz rocks, granite, etc., caused by the wear and tear of ages. Sometimes the process has not been carried so far, and instead of sand we have *gravel* or *shingle*, such as collects at the bend of a river, where the current runs less swiftly and so is unable to drag it further along. It is impossible to assign any limit of size beyond which these débris cease to be débris and have to be considered as part of the original rock; but one may say roughly that sand consists of particles ranging from the size of a small pea down to impalpable powder, gravel of particles ranging from a pea to a walnut in size, whilst shingle may range from that up to blocks a foot or more in diameter. Further, a distinction has to be drawn, in practice, between *rounded* sand and pebbles such as are found on a sea-beach, where the waves have been grinding the particles against one another till all corners are worn off, and *angular* fragments of more recent origin found in a quiet spot.



29. RIPPLE-MARKED SANDSTONE
From Wealdon

The various forms of quartz detritus known as sand, gravel, shingle, and pebbles form the raw material of the chief sandy rocks. They are again united into a solid rock in two ways. The mere pressure of the superincumbent strata is often sufficient to consolidate fine particles of sand into a coherent mass—just as powdered graphite is squeezed in a hydraulic press until it forms the solid lead for our pencils. In other cases the separate particles are held together by a hard cement, or *matrix*, which may be hardened sand or clay, or chemical cement precipitated from solution in water. The numerous varieties of sandy rocks owe their countless differences to the union of different kinds of particles by different kinds of cement.

Sandstone. *Sandstone* [29] is a rock formed of consolidated sand, held together by its own coherence or by a cement, which may be of iron oxide (which gives its colour to most of the red sandstones), of clay, of carbonate of lime, of silica, or other material. Thus, we have ferruginous, argillaceous, carbonaceous, siliceous, and yet other sandstones. If the grains of sand are somewhat coarse and angular, so that the stone, when broken, feels very rough to the touch, it is known as *Gritstone*.

Greywacke is the name given to a particularly compact and hard sandstone, of a prevalent grey colour, which is the hardened muddy sand of very ancient sea-floors. *Flagstone*, used for pavements, is a sandstone which splits into thin flags along the planes of bedding or stratification. *Freestone* is a sandstone which can be cut with equal ease in any direction, and shows no such tendency to split up.

Conglomerate. This, popularly known as *pudding stone* [30], is a rock in which the sand is replaced by gravel or shingle, held together by a cement which may consist of hardened sand or clay, or of the materials mentioned in the last paragraph. The rounded pebbles, which give character to the conglomerate, may be of quartz granite, limestone, or many other rocks.

Breccia. *Breccia* [31] is a rock in which the pebbles, instead of being rounded, as in conglomerate, are angular. The real distinction between the two is that conglomerate points to the action of water, which always tends to round pebbles exposed to its action, and breccia to atmospheric denudation (such as forms cliff screes and glacial moraines), which leaves the fragments much as they were when broken off by frost or other weathering influences.

Argillaceous, or Clayey, Rocks. These are composed of fine argillaceous sediment, derived from the waste of rocks, especially of granites and other rocks which contain the felspars as ingredients. *Clay* itself is a hydrated silicate of alumina, which is a product of the decomposition of felspar. It occurs in many varieties with differing compositions, of which *kaolin* or *china clay*, *pipe-clay* and *fire-clay* are well-known examples. *Brick-clay* is a name industrially given to the coarser clays. *Loam* is a mixture of clay and sand, which provides an excellent soil for many kinds of vegetation.

Loess, again, is a clay which has been accumulated probably by wind-drifts to the depth of hundreds of feet in the great river valleys of China, where it plays an important part in agriculture. *Boulder-clay*, or *till*, is a stiff, sandy clay, full of boulders of all sizes, which is found only where ancient glaciers once ground to powder all but the hardest fragments of rock, and in which these surviving fragments are still found embedded. All these, it will be remembered, are rocks in the geological, though not in the popular, sense of the word.

30. CONGLOMERATE, OR PUDDING STONE
From Woolwich and Reading Beds

Under pressure of overlying strata, ancient clays have hardened into compact rocks. *Mud-stone* is the intermediate stage between clay and rock, in the popular sense. It has no tendency to split into plates, and is easily rubbed down into mud with the aid of water. *Shale* is a general term given to any clayey rock which splits easily into thin layers; there are countless varieties, according to what other material—as iron pyrites, sand, limestone, or carbonaceous matter—happens to be present with the clay. *Oil-shales* are used in the manufacture of paraffin. *Slate* is a hard, clayey rock which splits into thin, regular plates along its cleavage planes, which are not necessarily the same as the bedding planes that represent the original surfaces of stratification. It is much employed in buildings, owing to this convenient property.

Calcareous Rocks, or Limestones. These consist mainly of calcium carbonate. The purest example is *chalk* [32], a soft rock which often contains more than 90 per cent. of calcium carbonate. It is composed of the shells and skeletons of minute organisms which once lived in primeval seas, from whose waters they extracted the calcium carbonate, which they built up into wonderfully beautiful, though microscopic, structures, which fell down to the sea-bed when the organisms died and rotted, ultimately forming deposits of hundreds or thousands of feet in thickness during the lapse of long geological ages. By far the larger number of *limestones* are similarly of organic origin. They vary in hardness and in chemical composition so widely that it is impossible to give any account of their varieties. It must be noted that in many cases limestone, though a true sedimentary rock, presents a crystalline structure, since it is soluble in water—especially if carbonic acid be present—and may crystallise out if it is again deposited from this solution. *Marble*, as we shall see later, is a limestone which has been crystallised by heat, and belongs properly to the section of metamorphic rocks.

31. BRECCIA

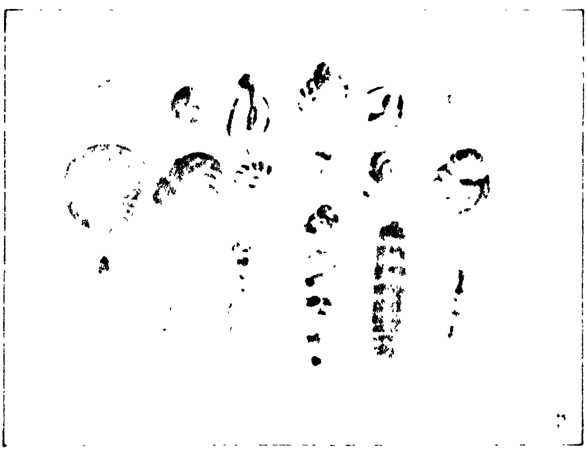
The *magnesian limestones*, or *dolomites*, are an important class of calcareous rocks, which consists of a mixture of calcium carbonate with magnesium carbonate. All limestones have the important property that when they are heated, or "burnt," the carbon dioxide (CO_2) is driven off as gas, and quicklime (CaO) is left behind [see CHEMISTRY]. They are easily recognised by the fact that they effervesce when acid is dropped on them, carbon dioxide being again given off and forming bubbles in the acid.

Among calcareous rocks we must note those containing phosphate of lime, which arise chiefly from organic sources, and are valuable for their use as fertilisers. These include *guano*, *bone-breccia*, *phosphatic chalk*, and the *coprolites*, or fossil excrement, which often occur in whole beds. Geologically these are of little importance, save as bearing witness to the earlier forms of life.

Carbonaceous Rocks. Carbonaceous rocks have almost all been derived from the decay of vegetable matter. They play an important part in human life as the chief sources of heat and power. Indeed, there is no rock, with the possible exception of the flint which first taught man to make himself tools, that has had so much influence on the course of human civilisation. *Peat* is the most recent form of carbonaceous rock, and can easily be recognised as recently decayed vegetation, found chiefly in boggy places. *Lignite*, or *brown coal*, is a more advanced stage in the mineralisation of vegetable matter, and occurs in strata more recent than those of the coal measures. *Coal* is a true rock, which contains 75 to 90 per cent. of carbon, along with oxygen, hydrogen, and nitrogen — the chief organism-building elements—and with impurities which are left as ash when the coal is burnt. For a special account of the numerous varieties of coal, with their special uses, the reader must consult the course on MINING. We need only mention *anthracite*, which is the most completely mineralised form of coal, and contains over 90 per cent. of carbon. The volatile constituents have been expelled from it, probably by the near approach of intrusive volcanic rocks, so that in a sense it is a metamorphic rock. The valuable Welsh *steam-coal* is a form of anthracite. *Petroleum*, which may be termed a liquid rock—as mercury is a liquid metal—at ordinary temperatures, is also a product of decayed vegetation, possibly due to the destructive distillation of coal under great pressure in the lower strata of the crust. *Asphalt* is probably of similar origin. *Graphite* occurs in large masses in places as far apart as Cumberland and Ceylon, and must be named under this head. Its origin is not clear, but it is known to be practically pure carbon, and may thus rank as the last step in the alteration of vegetable matter.

Other Sedimentary Rocks. There are a small number of sedimentary rocks which have found no space inside this classification, but must be mentioned in the course of such a review.

Siliceous Sedimentary Rocks are of organic origin, and consist of the shells and skeletons of marine organisms which chose to build their frail houses of silica rather than of limestone. The most important of these is *flint* [33], which is practically pure silica, partly amorphous and partly crystalline. It is found in nodules, usually dispersed through the chalk strata. It is believed that these nodules or lumps were formed by the chemical deposition of the silica of the sea-water around the nuclei afforded by the siliceous skeletons of dead sponges or diatoms. The great importance of flint from a human point of view lies in the fact that, though intensely hard, it can easily be chipped into shapes with sharp edges, and so lends itself more readily than any other material to the manufacture of primitive cutting instruments [34 and 35]. It is not too much to say that the whole fabric of our civilisation is based on flint.



32. PHOTOMICROGRAPH OF CHALK
(Magnified 100 diameters)

Crystalline Sedimentary Rocks. These, though not very common, do occur. We have seen that there are two ways in which a mineral may crystallise—either by cooling from a state of fusion, or by precipitation from a solution in water or other liquid. *Diamonds* are undoubtedly formed in the latter way, by the crystallisation of carbon which has been dissolved under great pressure in molten iron. *Rock salt*, which is found in beds hundreds of feet thick, and often assumes a crystalline structure, is clearly the relic of ancient seas or salt lakes which have gradually dried up. *Limestone* is often found in a crystalline form, due to the fact that it has dissolved in water containing carbonic acid gas, and has again been deposited in crystalline form. *Travertine*, or calc-sinter, is thus deposited by calcareous springs, while the *stalactites* and *stalagmites* of limestone caverns are of similar origin.

Volcanic Fragmental Rocks. *Volcanic fragmental rocks*, or *tuffs*, though not in the strict sense of the word sedimentary rocks, are usually included in this family. They consist of the materials ejected from volcanoes otherwise than in the form of lava. They vary in size from *volcanic bombs*, often several feet in diameter, to the impalpable *volcanic dust*, which floats in the air long after an eruption and slowly settles down on the earth, where it becomes stratified just as if it had been deposited by water. *Volcanic tuffs* are rocks formed of this kind of detritus, fine or coarse, which vary, according to the nature of their materials, from a coarse *volcanic conglomerate* to a fine-grained rock. They are found, of course, only in the neighbourhood of ancient volcanoes, and usually shade off into true sedimentary formations.

Metamorphic Rocks. There is a third class of rocks which are neither igneous nor sedimentary—that is, these rocks are no longer in the original state in which they solidified from the molten core of the earth's crust, nor yet have they been broken down and arranged in strata by the action of water or atmospheric influences. They have, however, undoubtedly been altered from the condition in which they were first produced, and accordingly they are described as *metamorphic* or *altered rocks*.

Their present state bears witness to the action of many and various agencies of change. Some of them are igneous rocks which have assumed a false stratification in consequence (probably) of the pressure of superincumbent layers or of pressure exerted from the side by the great deformations due to the shrinkage of the earth's crust and its consequent wrinkling into mountain ranges. Others are sedimentary rocks which have assumed a false crystalline character through the action of heat, usually due to their coming in contact with intrusive floods

33. NODULE OF FLINT
Showing imbedded fossil

of molten lava welling up from beneath the surface — *contact metamorphism*. *Marble*, for instance, is a metamorphic rock which is now crystalline. It was once sedimentary limestone, which has been melted under great pressure and has crystallised in cooling. If we heat limestone under the normal conditions which obtain at the earth's surface, it does not melt, but the carbon dioxide passes off as gas, and lime is left behind, as occurs in every lime-kiln. But if the limestone be enclosed in a steel chamber so strong that the pressure of the escaping gas cannot burst it, it is possible to melt it, and to produce a kind of marble in our laboratories, so illustrating the process by which marble was naturally produced when vast masses of limestone sank down far beneath the earth's surface and were exposed to the central fires under the immense pressure of miles of superincumbent strata.

34. PALÆOLITHIC INSTRUMENT
From the gravels of Swanscombe, Kent

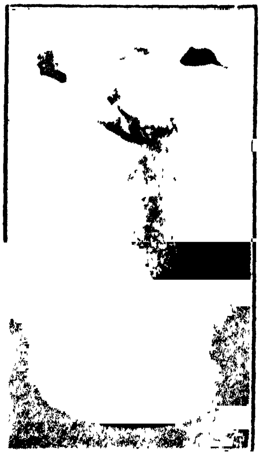
False Stratification. It is not necessary to enter into a detailed account of the various metamorphic rocks, which can be arranged in a long series, where every term shades into the next one, from the argillaceous *schists* closely resembling slates to the *gneisses* which can often be distinguished from granite only with difficulty. It is enough to say that these rocks are in general characterised by a double set of qualities which stamp them as intermediate between igneous and sedimentary rocks. They are crystalline, and they are arranged in layers or strata. Close examination betrays a typical distinction between these strata and those which mark the true sedimentary or stratified rocks. In the latter case the strata, or bedding-planes, indicate the successive layers in which these rocks were deposited by water or other agency. In the metamorphic rocks the stratification is produced in quite a different way. It is found by experiment that if a mass composed of crystals be subjected to powerful and long-continued pressure in a particular direction, the crystals which compose it tend to rearrange themselves so that all their longer axes lie in the same direction—just as the dates which have been squeezed into one of the lumps familiar in all grocers' shops are found to lie practically all in one direction. It is this rearrangement of the separate crystals which produces a false appearance of stratification in the metamorphic rocks.

Schists. A crystalline rock which has thus obtained a stratified structure as the result of pressure is known as a *schist*; it is often spoken of as being *foliated*, rather than stratified. A schist may also be the product of heat or chemical action upon a sedimentary rock, which gains a crystalline character without losing its stratified appearance. Practically all metamorphic rocks owe their origin to one or other of these causes.

The Schists are almost as numerous as the sedimentary and igneous rocks from which they are derived. Thus we have *clay-schist* and *quartz-schist*, which are both crystalline forms of clayey and sandy sedimentary rocks, while *quartzite* is a still more thoroughly crystallised sandstone. *Schistose conglomerates* are conglomerates in which pressure has produced a bedded structure by the arrangement of the pebbles into layers. *Crystalline limestone* and *marble* are also of sedimentary origin. *Gabbro-schist*, *hornblende-schist*, *mica-schist* and the like need little explanation. *Gneiss* is the term applied to the coarse schists which present characters resembling those of granite, some of which are volcanic rocks which have acquired a stratified character by alteration under pressure, whilst others are sedimentary rocks which have been crystallised by heat. This shows very prettily how diametrically opposed histories can end in nearly the same result in the great laboratory of Nature.

We shall now pass on to the second great division of geological study—*physical geology*, or the examination of the agencies at work to produce the sedimentary rocks which now cover the greater part of the earth, and give us our soil.

Continued



35. NEOLITHIC IMPLEMENT

Group 12
MECHANICAL
ENGINEERING
3

APPLIED MECHANICS
continued from page 964

HYDROSTATICS

The Pressure of Liquids, and its Mechanical Application. The Hydraulic Press. Pumps of Different Types. Accumulators

By JOSEPH G. HORNER

The Two Kinds of Liquids. Matter exists in three forms—solid, liquid, and gaseous. Liquids and gases have no definite shape, and cannot, like solids, resist the action of forces impressed upon them. They are therefore called "fluids." *Hydro-statics* (Gr. *hydro* = water, *statikos* = static, or standing), strictly speaking, deals only with non-elastic fluids—*i.e.*, liquids. Water is so slightly compressible that a pressure of 22 atmospheres (324 lb. per square inch) merely diminishes its volume by a thousandth part. There are widely varying degrees of resistance to change of shape among liquids. Water, chloroform, and alcohol move very freely and are called mobile liquids, but oil, tar, pitch, treacle, and honey move very, very leisurely, and are called viscous liquids. As this, however, is only a question of degree of friction between the particles composing the liquid, and as viscous liquids behave like mobile liquids if they are given sufficient time, this distinction is of little consequence in questions concerning the equilibrium of liquids. A perfect fluid would be one in which friction between the particles was non-existent, and in which there was therefore no resistance to alteration in shape. A moment's consideration would show that as a consequence of this the pressure of a liquid at any point of a surface on which it acts is always perpendicular to that surface at that point. Hence, in constructing embankments, dams, docks, and so on, the pressure of the water has to be considered as acting in the direction of the arrows shown in the three cases in **128**, **129**, and **130**. The pressure is always perpendicular to the surface of the wall, and if the latter be not strong enough, it will be pushed along on its base, overturned, crushed, or lifted, as the various arrows indicate.

How Engineers Use Water. The engineer may be said to regard and to use water in two ways. Pascal, over 200 years ago, investigated the behaviour of water under pressure, and a century later that marvellous inventor, Joseph Bramah, produced his hydrostatic press, the action of which is based on the great law Pascal discovered. The modern hydraulic press, capable of exerting anything up to 12,000 or 14,000 tons pressure, and under whose action steel yields like clay, is an illustration of one of the ways in which engineers use water—by communicating pressure to it in such a way that that pressure, as we shall see later, is enormously magnified. Secondly, water possesses of itself a huge power, due to the force of gravity. Sometimes this is utilised, as in water-wheels and turbines, and in the equivalent form of the accumulator, but just as often it is a force which the engineer is called upon to neutralise, as in the construction of dams, lock gates, and retaining walls.

The Principle of the Hydraulic Press. Pascal, that mystic and fascinating scientist, found that liquids possessed the property of transmitting equally in all directions pressure exerted at any point on their surface. This is well illustrated by the apparatus in **131**. The closed vessel, the shape of which is immaterial, is filled with water, and at different points in its surface are cylindrical openings fitted with pistons. Piston B = twice the area of A; C = three times A; D = four times A. Now, according to the law just stated, any pressure communicated to the water by a piston will be transmitted with undiminished intensity in all directions inside the vessel. If the other pistons had the same area as A, and the latter were pressed inwards with a pressure of 40 lb., B, C, and D would each be forced outwards with a pressure of 40 lb. (in addition, of course, to the pressure previously sustained from the water itself). But as the area of each piston is double that of the preceding one, this 40 lb. pressure at A would become 80 lb. at B, 120 lb. at C, and 160 lb. at D. As the area is multiplied, so is the power. The same law is illustrated in the apparatus known as hydrostatic bellows or hydrostatic paradox [**132**]. AB and CD are circular boards connected by leather bellows; the tube E opens into the interior of the apparatus, and through it water is poured until the bellows are distended as far as it is possible. Heavy weights—even the weight of a man—may be placed on AB, and supported by the weight of the small column in the tube. In this way AB could be made to raise and support a hundredweight if the tube held 1 lb. of water and the area of AB were 112 times that of the tube. It must not be forgotten that this multiplied transmission of pressure is entirely due to the incompressibility of water.

How Hydraulic Presses Work. We are now able to understand the action of that wonderful machine, the hydraulic press, as it is constructed to-day, or, as it is sometimes called, Bramah's press, from the name of the inventor who devised its principle of operation. A [**133**] is a force pump which, operated by the lever handle B, pumps water from the chamber C, through the pipe D, into the strong cylinder E, thus forcing upwards the ram F. Let us consider its working in detail. On raising the handle B, the plunger P is lifted, the valve G at the bottom of the cylinder A is raised, and water enters from the reservoir C. On pressing down the handle B, the valve G closes, and another one (not shown) opens in the pipe D, through which the water is then forced. (An enlarged, detailed view of a pump of this type is shown in **144**.) Imagine this to be continued until the cylinder E is full. When this occurs, we have a state of affairs analagous to that just described in the hydrostatic bellows. The pressure imparted by the plunger P is transmitted undiminished to the piston F, but owing to the greater diameter of F over P this pressure is enormously magnified, and is multiplied in the ratio of the areas of the two cylinders. If the diameter of the plunger P be ¼ in., and that of the ram F 10 in., the ratio between their areas will be as 1 : 1,600. Therefore a pressure of 1 lb. on the plunger becomes an upward thrust of 1,600 lb. on the ram. If W = load or weight supported, and P = the load on or force applied to the plunger, then $\frac{W}{P} = \frac{D^2}{d^2}$, D being diameter of ram, and d diameter of pump plunger. From this formula it is clear that the mechanical advantage could be theoretically increased so as to produce an enormous multiplication of force—merely by increasing the ratio of the areas of plunger and ram. But in practice it is found that the strength of the sides of the cylinder necessary to sustain such great pressure places some limit to the power which might be obtained from the application of this law of transmission of pressure.

How Gravity Affects Liquids. Turning now to the pressure water exerts owing to its weight, a very important law runs as follows: *The pressure at any given depth depends directly on the vertical depth below the surface.* This, of course, is self-evident. The liquid may be considered to consist of horizontal layers, those at a great depth sustaining all the layers above. The weight of a cubic foot of water is 62½ lb., and this would be the pressure on an area a foot square at a depth of 1 ft.; at a depth of 2 ft. the pressure would equal 2 × 62½ or 125 lb.; at 6 ft., 6 × 62½ or 375 lb.; at D ft., D × 62½ lb. If instead of a base of 1 sq. ft. the surface pressed contained A sq. ft., then the total pressure P = D × A × 62½ lb. If the liquid in question be not water, its weight per unit volume (W) would be substituted for 62½, and P = D × A × W.

Strange as it seems, the pressure of water on the base of a vessel is entirely independent of the *quantity* of water the vessel contains. The pressure on the base of a full decanter would be the same if its sides were vertical or tapered towards the mouth like an inverted funnel instead of bulging, as long as the area of base and depth of liquid remained unchanged. Yet in one case it might hold a quart, in the other a pint.

In measuring the pressure of water against dams, etc., the formula P = D × A × 62½ will not be correct, for, as the pressure varies with the depth, an *oblique* or *vertical* square foot or yard will not have uniform pressure all over its surface; the part nearer the surface sustains less than the deeper parts, and this explains why in cast-iron water reservoirs and tanks, and in foundation caissons, the lower plates are made thicker than the upper ones. It is necessary to take the average pressure, and this is equal to the pressure at the centre of gravity. So the rule for finding the pressure against any surface becomes P = Area of surface pressed × vertical depth of the C.G. of the surface × 62½. Let it be required to find the total pressure against the retaining wall in **134**. Suppose the wall 30 ft. long, and the depth of water (E), 20 ft. The wetted area therefore = 30 × 20 = 600 sq. ft. The vertical depth of the centre of gravity of the surface pressed below the surface of the water is in such a case half the depth of the water, or 10 ft. Hence the total pressure against the wall = 600 × 10 × 62½ lb. = 375,000 lb. = over 167 tons.

Retaining Walls. We have seen in the preceding paragraph how the total water pressure against a retaining wall may be estimated. In calculating the thickness and weight of wall necessary to prevent it being overturned or fractured it is convenient to consider this total water pressure as concentrated at one particular point in the wall, which is called the *centre of pressure*. It is the point at which the resultant of the fluid pressures acts, and these pressures constitute a system of parallel forces with a resultant equal to the total pressure. If an equal and opposite force—*i.e.*, the equilibrant—were applied at this spot, the surface would be kept in equilibrium. A concrete example will render this clearer. Imagine a long, narrow trough or cistern, one of whose ends, instead of being fixed, is free to slide along the length of the trough. If the trough be filled with water the movable end will be forced right out unless it be kept in position by the pressure, say, of the thumb. Now, if the thumb be applied near the top of the surface the water would push out the lower part, and if applied at the bottom, the water would force the upper part outwards. But there is a certain point at which the counterbalancing pressure might be applied, so as to keep the loose end in position and sustain the water pressure. That point is the *centre of pressure*. In the case of a horizontal area the centre of pressure coincides with the centre of gravity, but in the case of a sea-wall, where pressure increases with every unit of depth, it lies below the centre of gravity, and is found to be at two-thirds of the vertical depth below the water surface.

In **134** the pressure P is concentrated at the arrow head, one-third up from the bottom, and it acts in a horizontal direction. P will tend to overthrow the wall by making it turn about B, the moment of the water being P multiplied by BD, the latter in this case being one-third of the depth of the water. The moment of stability of the wall is the product of its weight (concentrated at its centre of gravity G), and the distance AB. If the moment of the wall be less than the moment of P, the wall will be overturned by the pressure of the water. (Generally, in calculations of this sort, the wall is assumed to be one foot in length, so that the total square feet of area of its vertical section also represents the cubical contents, and when multiplied by the weight of a cubic foot of the material of which the wall is composed, the total weight is obtained.) In actual practice retaining walls are made thicker than the overthrowing moment demands, especially where waves have to be considered. And as regards the form of the wall, although it is found that the stability is greater when the water presses against the sloping side, yet the danger of crushing and fracture often renders it advisable to sacrifice a degree of stability and let the vertical side receive the pressure.

Specific Gravity. Before touching the question of flotation and buoyancy it is necessary to have an exact notion of what is meant by specific gravity. The specific gravity (abbreviated sp. gr.), of any body is its weight, as compared with that of an equal bulk of water, though of course any other substance would serve as a standard of comparison. In the case of gases, air or hydrogen is the standard or unit. Now, as the volume of water or any other kind of matter changes with alteration in temperature, it is necessary that one particular temperature should be decided upon. As water has its greatest density at 4 degrees C. (39·2 deg. F.), that is the temperature generally adopted. Frequently, however, specific gravities are measured at the more convenient temperature of 60 degrees. A cubic centimetre of water at 4 deg. weighs 1 gramme. With this, then, as a unit, the sp. gr. of any substance is its weight in grammes per cubic centimetre. When we say that the sp. gr. of gold is 19·25, copper 8·7, lard ·95, wine ·9, Bath stone 2·1, alcohol ·79, cork ·24, we mean that these figures represent the weight in grammes of a cubic centimetre of these particular substances; or that the weight, say, of a cubic foot of gold is 19·25 times the weight of a similar volume of water, and that the ratio between the weights of a cubic foot or inch of cork and water is as ·24 is to 1.

The specific gravity of a substance not acted on by water and of greater sp. gr. than water can be found by weighing it first in air, and then in water, and dividing its weight in air by the loss of weight in water. If A = wt. in air, and a = wt. in water, then

$$\text{Sp. gr.} = \frac{A}{A - a}.$$

If a substance weighs 54·3 grammes in air, and 47·8 in water, its

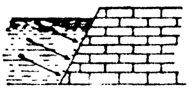
$$\text{Sp. gr.} = \frac{54\cdot 3}{54\cdot 3 - 47\cdot 8} = \frac{54\cdot 3}{6\cdot 5} = 8\cdot 3.$$

If the body floats in water, this method is useless, and a weight called a sinker is attached to the body, which is specifically lighter than water, to make it sink. If A = weight of body in air, B = weight of sinker in air, a = weight of body and sinker in water, b = weight of sinker in water, then the sp. gr. of the body $= \frac{A}{A - a + b}$. Specific gravity may be calculated in several other ways, but by means of an instrument called a hydrometer the sp. gr. of any liquid may be rapidly determined by noting on a graduated scale the depth to which the instrument sinks. With Nicholson's Hydrometer the sp. gr. of either a liquid or a solid may be found.

Buoyancy of Liquids. If a man plunges into a river, or a stone be thrown into a pond, a bulk of water is displaced exactly equal to the bulk of the body which enters and is immersed in the water. If it be partly immersed, as in the case of a ship, or a man floating, then the bulk of water displaced equals the bulk of the immersed portion only. That is quite obvious. Whether it be a case of total or partial immersion, two forces act on the body: that of gravity, which tends to make it sink to the bottom, and the upward force of the water tending to thrust the body upwards to the surface. Whether the body shall float, or sink to the bottom, or remain stationary at a certain depth, depends on the relative intensities of these two forces.

Over 2,000 years ago Archimedes stated the law governing the amount of upward pressure to which a body is subjected when placed in a liquid. He found that *a body immersed in a liquid is buoyed up with a force equal to the weight of the liquid it displaces.* If a cubic foot of the liquid weighs the same as a cubic foot of the solid—*i.e.*, if their specific gravities are the same—the body would remain at rest at any depth; if, as in the case of lead, the solid is specifically heavier than the liquid, the weight of the solid is greater than the weight of the displaced liquid and will sink. And the force with which it will descend equals the difference between their specific gravities. Thus, the specific gravity of lead is 11·38, so that with a cubic foot of water weighing 62½ lb., and a cubic foot of lead weighing 709 lb., the force with which lead would sink is 709 − 62·5 = 646·5 lb. In the case of a light substance such as cork or wood, its weight will be less than the weight of water displaced, and so it will be buoyed upward with a force equal to the difference between the weight of the displaced liquid and the solid. From this it is evident that a floating body such as a cork or a ship displaces its own weight of the water it floats in. Therefore the weight of any floating body may be easily calculated, for it equals the volume of water displaced, in cubic feet, multiplied by 62½ lb. Conversely the draught can be found if the weight and dimensions of the body are known.

The fact that a swimmer cannot sink in the Dead Sea, and that coins, stones, etc., float easily on mercury, is easily explained by the principle of Archimedes. The sp. gr. of Dead Sea water is 1·2 as compared with ·89 for the human body (alive). A living person would thus displace a quantity of water of greater



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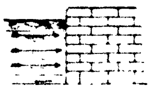

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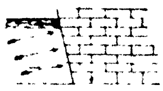

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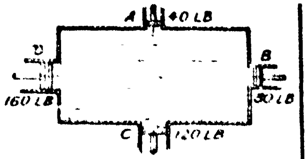

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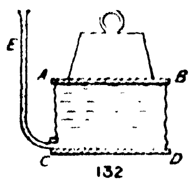

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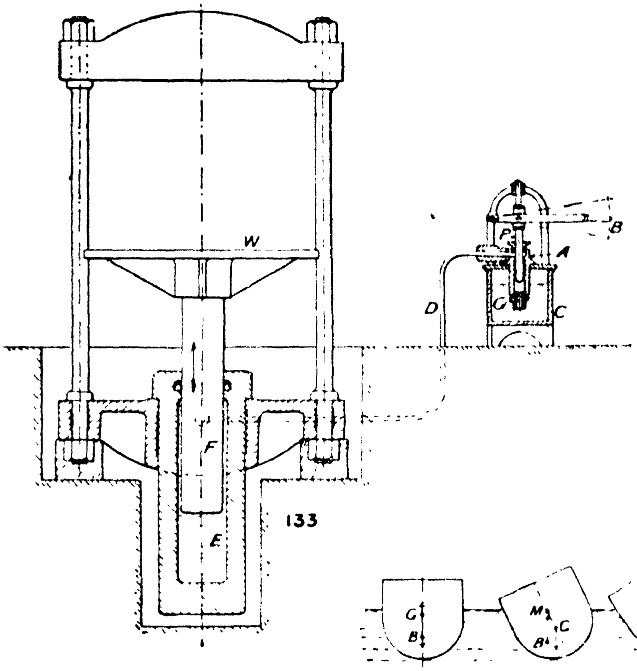

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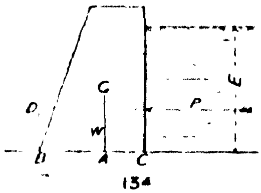

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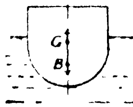

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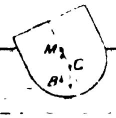

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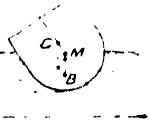

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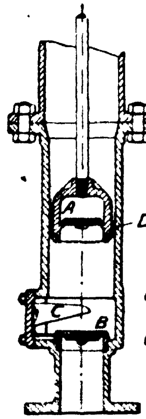

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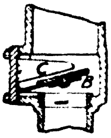

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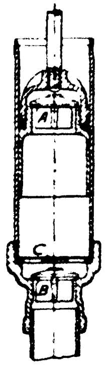

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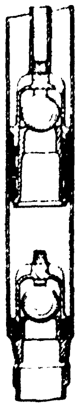

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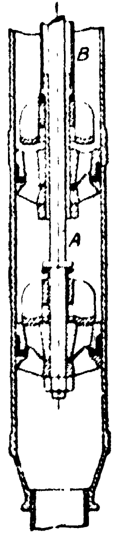

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weight than his own body and hence would be thrust upwards till he reached the surface. The sp. gr. of mercury is 13·58. A cubic foot of mercury weighs over 7½ cwt., but there are very few solids a cubic foot of which would weigh so much. Therefore, when immersed in mercury they displace a volume of the liquid of considerably greater weight than their own and so rise. Even when floating, the solid will only displace its own weight of mercury, and hence in many cases only the slightest fraction of a solid will sink below the surface.

The Metacentre. The stability of a floating body depends on the position of that important point called the metacentre. In a ship, for example, the position of this point means all the difference between regaining the vertical, and capsizing when rolling in a rough sea. The two forces which keep a floating body in equilibrium—(*a*) the downward force of gravity and (*b*) the upward pressure of the water (equal to the weight of water displaced)—may be considered to act (*a*) through the centre of gravity of the body, at G in **135**, and B, which is the resultant of all the upward and parallel pressures through the centre of gravity of the water displaced at B. This latter point is called the *centre of buoyancy* and the line joining G and B is the *axis of flotation*. Now if a force be applied to the floating body so that it heels over as in **136**, **137**, the centre of gravity of the water displaced will be shifted, as shown, and the point M where a vertical line from the new centre of buoyancy cuts the axis is the *metacentre*. It is important to remember that the pressure of the water acts upwards in the direction of this line. In **135** G and B are in the same vertical line, and the body floats in equilibrium. If it be disturbed, B will change its position with every change in the position of the body, but if, as in **136**, the point where the vertical line from B cuts the axis lies above the centre of gravity, the upward thrust, acting in the direction of this line, will tend to make the body regain its former position. It is then said to be in "stable" equilibrium. But should this metacentre fall below the centre of gravity [**137**], the force acting through BM will tend to make the body depart still more from its original position until it finds a new position of equilibrium. This, of course, means upsetting or overturning, and is termed "unstable" equilibrium. It may happen that the relative positions of B and G are not changed by the disturbance of a floating body, and that the line BM meets the axis of flotation always at G. This is so in the case of a sphere or a cylinder turning on its longitudinal axis. We then have an example of "indifferent" or "neutral" equilibrium. Ships are ballasted in order to bring the centre of gravity so low down that the metacentre shall always be above it.

Practical Examples. In selecting practical examples of hydrostatics, far more must be omitted than can be illustrated, because the applications of water power are so numerous and important. They occur in shops and factories, in docks and harbours, in warehouses and stores, in small and large installations. They are used in many trades, and are more adaptable to some operations than any other power agency, while in some they have an absolute monopoly. Water power is silent and strong, silent though squeezing white-hot steel with a pressure of 8,000, 10,000, or 14,000 tons, or while opening the huge gates of docks, or pressing hay and fodder into bales, or lifting a trifle of 100 tons. It is capable, too, of the most precise and minute regulation within fractions of an inch, by the control of the water supply. In some spheres of action it is being ousted by electricity, but a wide and undisputed field is still retained by water. The principle underlying all this great group of pressure machinery is that of difference in areas, embodied in the old Bramah press, and its modern equivalent [**133**]. Pressure is proportional to area, so that the elements of design are absolutely simple. The difficulties which arise are those of risk of leakage, those due to friction—which is considerable—and the necessity for securing ample strength in cylinders subjected to pressures that ordinarily range from 700 to 1,500 or 2,000 lb. on every square inch, or still more in some cases.

Head of Water Unnecessary. The problems of *head* of water have been considered in previous paragraphs. But the machinery in question does not now utilise natural head in order to obtain pressure, though that was done in the early days of the hydraulic cranes. Not until Armstrong invented the accumulator did the success of the water pressure system become assured. This consisted originally of a large cast-iron cylinder fitted with a loaded plunger to impart pressure to the water. At once the gravity pressure of some 60 lb. to the square inch was abandoned for 600 lb. In an ordinary hydraulic plant, therefore, we have three elements—the accumulator for water storage under pressure, the force pumps and engines, by which the pressure is produced, and the working cylinder, or cylinders and rams, by which pressure and movement are applied to any particular mechanism, and which occurs in an immense number of forms.

The following is a very concise summary of *hydrostatic* mechanism, or, as it is commonly termed, *hydraulic* machinery.

At the basis of it all lies the pump in some form or another. The common lift or suction pump of wells and tanks plays but a small part here, but combined with another form, the plunger, it is a valuable agent for lifting water from great depths. Few mechanisms are varied more than are lifting-pump valves. A complete study of these would require a big volume. Deep and shallow wells, different kinds of liquids, clean or dirty, hot or cold, questions of accessibility, and so on require modifications in valves.

Pumps. The pumps of the hydrostatic group are very broadly divisible under two heads, the lift or *suction* type, and the *force* pump. The important distinction between the two is that the first-named depends for its action on atmospheric pressure, and the second does not. It is usual to include these under the pneumatic branch of mechanisms, because the atmospheric pressure exercises an essential influence in the operation of the suction type. But it is more convenient, from the point of view of practical applications, to dispose of them here.

The suction group, and the pressure group are found in many and varied designs. The first are limited to depths of water of about 24 ft., the second have practically no limitations. These, the *force pumps*, as they are called, are the ones that are invariably employed for pressure purposes, since there is no limit to pressure possible, save that of the strength of the bodies, and fittings, and valves of the pumps themselves.

The air enters into the operation of all pumps, only in the suction pump it is far more important than in the others. The point in the first-named is that there is nothing but the atmosphere as the acting agent, its pressure alone forcing the water up through the suction pipe and barrel, through the delivery valve. The limiting height is that from the delivery valve at the top of its stroke to the water-level in the well.

Suction Pumps. Figs. **138—142** are a selection of the essential mechanisms of various suction pumps. Fig. **133** is the common lift, or atmospheric pump in its most familiar form, with bucket A, having a hinged leather and metal-plated valve, and the clack B, also of leather, hinged and weighted with metal plates. The clack is prevented from rising too high by the stop piece C, as shown in **139**. Leakage past the bucket is prevented by the leather packing D. Fig. **140** is a form less liable to get out of order than the one with leather fittings, besides being suitable for liquids that would destroy leather. The bucket-valve A, and the clack-valve B, are of the mushroom form—direct lifting. Both are prevented from lifting too high, A by the arch of the bucket, and B by the perforated plate C. If one of these valves opens to a height equal to one-fourth of its diameter, it will pass all the water of which it is capable.

A design often preferred is that with ball valves [**141**]. The advantage of these is that they will not only lift, but rotate slightly and constantly on their seatings, so equalising wear. Sometimes the mushroom valves in **140** are made with their wings disposed spirally, to cause them to turn slightly on their seatings at each lift. The height of lift of the ball valves [**141**] is slight, and each valve is enclosed in a cage with open sides, through which the liquid escapes. The example shown is one by Hayward, Tyler & Co., for deep wells.

The theoretical height of 34 feet can never be reached, due to leakages past the valves, and these may be so great in pumps having badly packed valves, or dried leather valves, as to prevent any lift of water until the leakage has been overcome by "fetching" the pump with water. The atmosphere at the commencement of pumping occupies the suction pipe. On lifting the bucket, the air expands, with loss of pressure, and the external air forces water up to occupy a portion of the vacuum. When the bucket has been lifted and depressed a few times, no free air is left, and the pump lifts solid water.

Air-pumps are also suction pumps. They draw the condensed steam and vapour mingled with air from the surface condensers of steam-engines. They are a group by themselves, having little resemblance to the pumps just noticed, though based on the same principles. Like these, too, though atmospheric pumps, they lift water charged with air when in full operation.

The first thing one notices about the action of the suction pump is that it discharges water only on the lifting stroke, or intermittently. This is objectionable for feeding purposes, and hence we have the treble-barrel arrangement. In this, three pumps are set side by side, each complete in itself, but driven from a common crank shaft, the cranks of which stand at 120° apart. Practically, a continuous delivery is thus obtained. In such pumps, the handle is discarded for a belt, or engine drive. Except for agricultural and domestic purposes, the lever handle is seldom used for pumps, but some form of power drive is applied.

Another way in which a practically continuous stream is obtained is in the double-action pump [**142**]. Here, the rod A of the lower bucket passes through the rod B of the upper one, and both are crank driven in such a way that the buckets move in opposite directions, one lifting while the other is forcing, a partial vacuum being formed between the buckets. The bottom bucket takes the place of the fixed valve in the previous figures.

Force Pumps. In these, a solid plunger or ram is substituted for the bucket with a valve, or valves, and the delivery valve is in a portion of the pump body away from the ram. The ram, therefore—a solid piston—alternately creates a vacuum into which the water flows through the suction valve, and then forces it through the delivery valve. Water can be raised through great heights thus, or what is equivalent, against great pressures, as when used for pumping into steam boilers. Also, the ram being independent of the valves, it may occupy either vertical, horizontal, or angular positions. This pump is also intermittent in action, delivering its water in a series of impulses, unless mounted in three-throw style, or fitted with an air vessel.

Plunger and Bucket Pump. There is another way of obtaining a continuous supply—namely, by the combination of a ram plunger with a bucket. Here, a bucket A, with valve, lifts the water, but on the down stroke the ram B displaces a volume of water equal to its own, and sends it out through the delivery valve C. Water being, therefore, discharged during both strokes, the supply is continuous.

Double-acting Pumps. Though the foregoing pumps may be made to yield a continuous supply, yet they all suck water on one stroke and discharge it on the next, and are, therefore, nominally single-acting. When good duty is required, such designs are too wasteful, and then pumps that suck and discharge on each stroke are designed, hence termed double-acting, or duplex pumps. There are a good many of these. The two best-known forms are that in which a single piston operates two sets of suction and discharge valves arranged at opposite ends of a common chamber, and the Worthington type. In this, two pump chambers and engine cylinders are arranged side by side. The steam piston and pump pistons are at opposite ends of their rods, and the slide valves are operated by the piston of the fellow-engine. The pumps draw from a common suction pipe, but each chamber has its own suction and delivery valves. An air vessel is common to both.

The Test Pump, or Hydraulic Force Pump. This is a ram pump [**144**] indicated in connection with the press [**133**], in which the water, practically incompressible in itself, is forced by a single-acting solid piston through valves and passages against the resistance of the work to be done. The latter may be anything, but is essentially a mass resistance. It will be observed that the valves bear but a small proportion to the mass of metal in the body of the pump, which is usually specified to be strong enough to resist a pressure of 2,000 lb., or more in some cases, to the square inch. The body is of gun-metal, as are also the suction and delivery valves A and B. The ram C is actuated by the lever B [**133**], and the water flows out through the passage indicated by the arrow. D is a relief valve for releasing the pressure by the lever seen above, the pressure water flowing away *through* E. *The perforated rose,* F, *prevents any solid particles getting into the valves. The relation of this to the common force pump,* one form of which is shown in **145**, will be obvious. The ram and valves are there, but the proportions are different, the pump [**145**] being suitable for pressures of from about 60 to 100 lb.

Air Vessel. The air vessel mentioned just now is not used on test pumps like **144**, because the volume of water pumped is extremely small, and has not to traverse far. In other words, there is no chance for the water to become saturated with air. But for long deliveries and for moderate pressures the air vessel is essential. One form is seen in **146**. It is made with a spherical end to ensure strength. Sometimes water will find its way through the pores of inferior qualities of iron. This vessel [**146**] is a chamber of large dimensions, fitted somewhere on the delivery side. It contains air, which, being elastic and compressible, becomes a cushion to the water that rises a little way into its neck during the delivery stroke. When the backward non-delivery movement takes place, the air, thus compressed, forces down the water that had invaded the chamber, sending it along after the rest, so that a practically continuous stream results.

Simple examples of the utilities of the test pump [**144**] are the testing of steam boilers, and steam and water pipes, or the lifting of a baling press. The resistance is that of the metal in the first, or of the material to be compressed in the last. As the water will not yield, the tug-of-war lies between the strength of the pump on one side and that of the boiler, or pipe, or press on the other. Then there is the utility of the pump for charging accumulators. As there comes a time when something would have to yield, the pressures are recorded on a dial gauge, and the pumps are fitted with relief valves. An advantage of these pumps is that the pressure may remain on for several hours, which is often a severe trial of strength of a boiler. These pumps occur in many forms, some being operated by hand levers, others directly connected to steam engines or electric motors.

The Accumulator. As pumps are too slow in operation for rapid work, the accumulator [**147**] is fitted where rapid action is required. For example, imagine how slow would be the movement of a hydraulic lift at a railway station if it were actuated directly by a pump; and the movements of a crane, also, or of a steel ingot press, or of a flanging press. In such cases the pumps fill the accumulator until it is charged with many gallons of water under a pressure of from 700 to 1,500 lb. per square inch, the latter being equal to 100 atmospheres. On opening communication between the accumulator and the lift, or crane, or press, the pressure-water works it at a speed capable of regulation. The pressure or resistance of the accumulator is obtained by loading its casing with weights to the 700 or 1,500 lb. required per square inch.

In **147** the parts are as follows: The pressure-water entering at A raises the ram B in the cylinder C, standing on the base H. The cross-head D attached to B, rising with it, receives rod E, on which is hung a plate, F, carrying a number of circular weights, G. The water being pumped, therefore, has to overcome the resistance of these weights, which, when raised, become the source of stored-up energy for doing work by their descent. The water passes to the machine, being operated through a tube (not shown) similar to A. The weights are made removable to permit of regulating the pressure according to the number used at any time. For convenience, it is arranged that each weight makes a difference of 100 lb. in the pressure. In the older accumulators, and in many at present, a casing of sheet metal (the weight-case) is used instead of F, and loose stone or iron is loaded in. The advantage of this is that the expense and trouble of transporting weights is avoided, since any rubble may be used on the spot. The cast weights already mentioned provide a convenient means of regulating the pressure with precision, as stated.

We have now to note some of the common applications of the hydrostatic press and accumulator to manufactures and industries, which will occupy the next article of this course.

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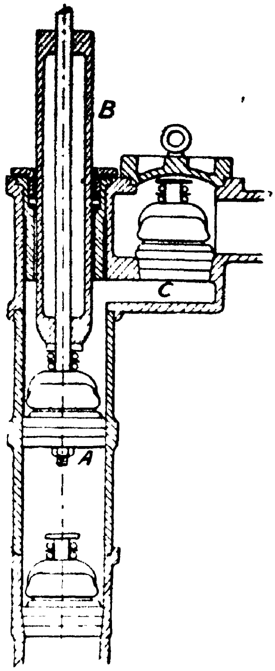

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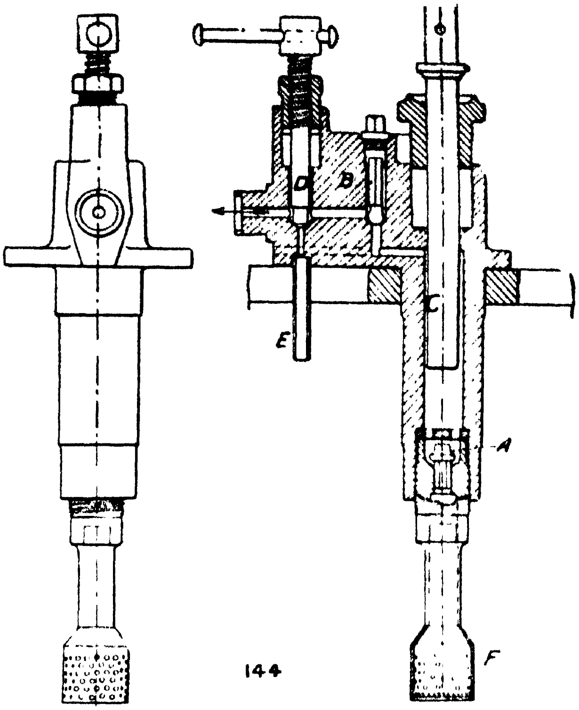

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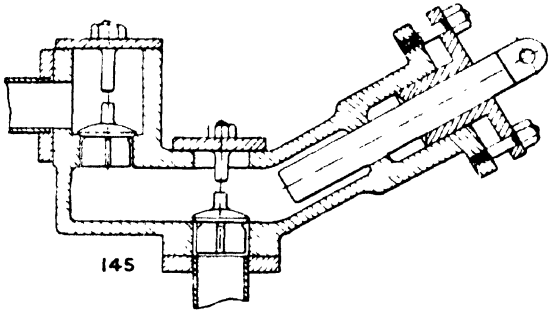

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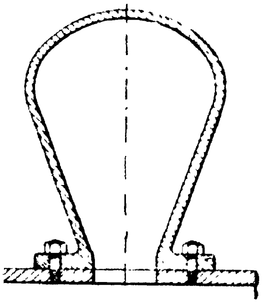

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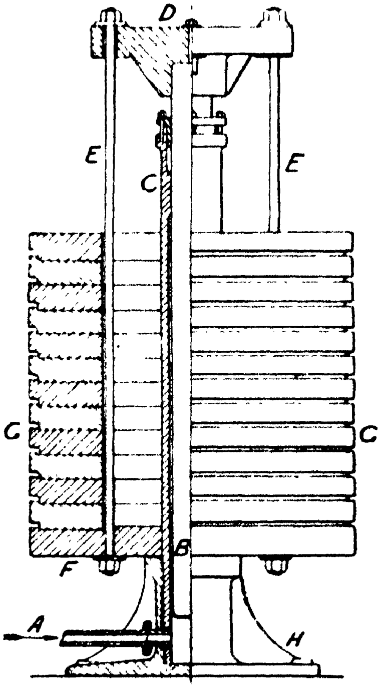

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FORCE PUMPS, AIR VESSEL, AND ACCUMULATOR

Group 8

DRAWING

8

Continued from page 1016

PRACTICAL GEOMETRY & OBJECT DRAWING

Inscribed and Circumscribing Figures. A Lesson in the Drawing of the Skeleton Cube and Vases; with a Note on Memory Drawing

By WILLIAM R. COPE

INSCRIBED AND CIRCUMSCRIBING FIGURES

284. About a Given Triangle *ABC*, to Describe another Triangle similar to a Given Triangle *DEF*. On *AB* construct a triangle similar to the triangle *DEF*. Through *C* draw a line parallel to *AB*, and produce *GA*, and *GB* to meet it. Then *GHJ* is the triangle required.

285. About a Given Square *ABCD*, to Describe a Triangle similar to a Given Triangle *EFG*. On *AD* construct a triangle similar to *EFG*. Produce the sides to meet *BC*, produced as shown.

286. Within a Given Triangle *ABC*, to Inscribe another Triangle similar to a Given Triangle *DEF*. On *AB* construct a triangle similar to *DEF*. Draw *GC*. From *H* draw *HJ* and *HK* parallel to *GB* and *GA* respectively. Join *JK*. Then *HJK* is the required triangle.

287. To Inscribe an Equilateral Triangle in a Given Square *ABCD*. Draw the diagonal *AC*. On *AC* construct an equilateral triangle *ACE*. From *D* draw *DF* and *DG* parallel to *EA* and *EC* respectively. Join *F* and *G*.

288. To Inscribe a Square in a Given Triangle *ABC*. Draw *AD* perpendicular to *BC*. From *A* draw *AE* parallel to *CB* and equal to *AD*. Draw *EC*. From *F* draw *FG* and *FH* parallel to *BC* and *AD* respectively. From *G* draw *GJ* parallel to *AD*. Then *FGJH* is the required square.

289. To Inscribe a Square in a Trapezium *ABCD*. Draw the diagonals *AC* and *BD*. Draw *AE* parallel to *BD* and equal to *AC*. Draw *BE*. From *F* draw *FG* and *FH* parallel to *BD* and *AC* respectively. From *G* draw *GJ* parallel to *AC* and join *JH*.

290. To Inscribe a Square in a Given Sector *ABC*. Join *B* and *C*. Draw *CD* perpendicular and equal to *BC*. Draw *AD*, and from *E* draw *EG* and *EF* parallel to *CB* and *DC* respectively. Draw *GH* and *FH* parallel to *EF* and *EG*.

291. To Inscribe a Square in a Segment *ABC*. Bisect the chord *AB* of the segment in *J*. Draw *BD* equal and perpendicular to *AB*. Draw *JD* and produce it to cut the arc in *E*. From *E* draw *EF* and *EG* parallel to *DB* and *BA* respectively. Draw *GH* parallel to *EF*. Join *FH*. Then *GHFE* is the required square.

292. Within a Given Circle, to Inscribe a Triangle similar to a Given Triangle *ABC*. At any point *D* in the circumference of the given circle draw a tangent *EF*. Make the angle *EDG* equal to the angle *CAB* and the angle *FDH* equal to the angle *ABC*. Join *GH*. Then *DHG* is the required triangle. [Euc. IV. 2.]

293. About a Given Circle, to Describe a Triangle similar to a Given Triangle *ABC*. Produce the base *BC* of the given triangle. Find the centre *L* of the given circle, draw any radius *LG*, and produce it. Construct the angle *FLG* equal to the exterior angle *ACD*, and the angle *HLG* equal to the exterior angle *ABE*. Produce *LH*, *LF*, and draw tangents as shown. [Euc. IV. 3.]

294. To Describe a Square About a Given Isosceles Triangle *ABC*. Bisect the base *BC* of the given triangle by the line *AD*. On *BC* describe a semicircle. Then *AD* will be a diagonal of the required square. Draw *DC* and *DB* of indefinite length, and from *A* draw parallels to meet them.

295. In a Given Hexagon *ABCDEF*, to Inscribe an Isosceles Triangle, the Base *HJ* being Given. Draw the diagonal *AD* of the given hexagon. Draw *CE* at right angles to *AD*. Set off *EK* equal to *HJ*. Draw *KL* parallel to *ED*, and *LM* parallel to *CE*. Draw *AL* and *AM*.

296. Within a Given Circle, to Inscribe an Isosceles Triangle, the Base *AB* being Given. Draw two diameters of the given circle *CD* and *EF* at right angles to each other. Make *GH* equal to half the given base *AB*. Draw *HJ* parallel to *CD*, and *JK* parallel to *EF*. Draw *CJ* and *CK*. A similar method may be used for inscribing an isosceles triangle in a square, rhombus, or polygon.

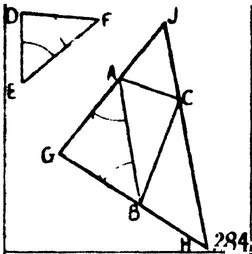
297. Within a Given Square *ABCD*, to Inscribe another Square, one Angle to Touch a Side at a Given Point *E*. Draw the diagonals of the given square. With centre *F* and radius *FE* describe a circle. Join the points *E*, *G*, *H*, *J*.

298. To Inscribe a Rhombus in a Given Parallelogram *ABCD*, having One of its Angles at a Given Point *E*. Draw the diagonals of the parallelogram. From *E* draw *EF* passing through the centre *G* of the parallelogram. Through *G* draw *HJ* at right angles to *EF*. Draw *EJ*, *JF*, *FH*, and *HE*.

299. To Inscribe a Square in a Rhombus *ABCD*. Draw the diagonals, and bisect the angles thus formed. Join *E*, *F*, *G*, and *H*.

300. To Inscribe a Square in a Hexagon. Draw the diagonal *AB*, and bisect it at right angles by the diameter *CD*. Proceed as in 299.

301. To Inscribe a Regular Hexagon in an Equilateral Triangle *ABC*. Bisect each of the angles of the given triangle by the lines



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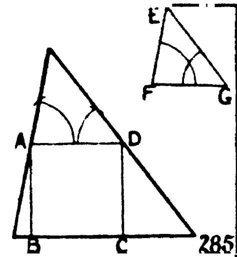

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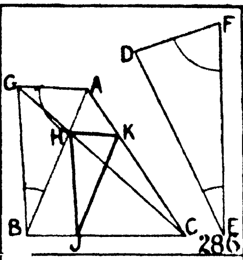

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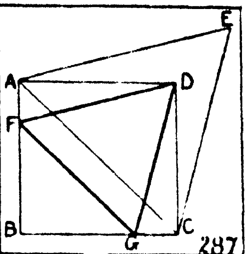

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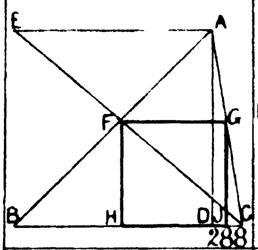

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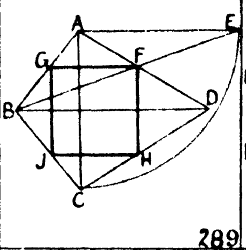

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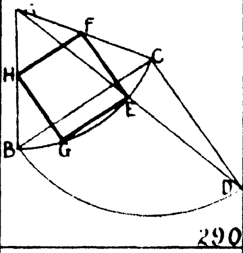

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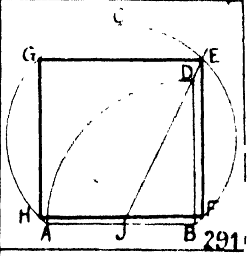

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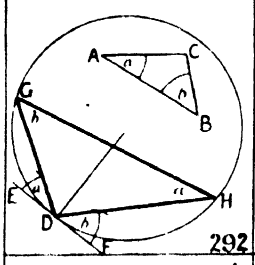

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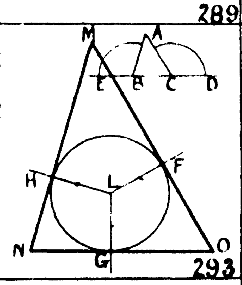

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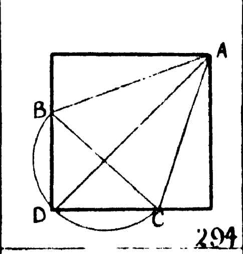

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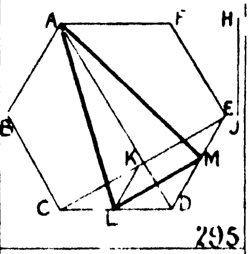

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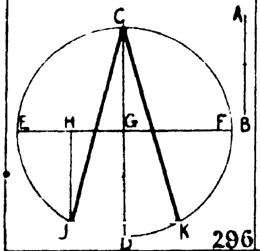

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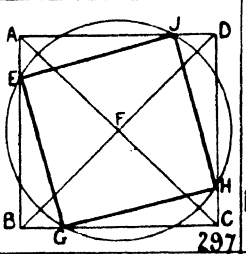

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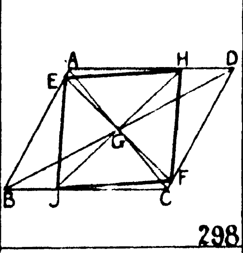

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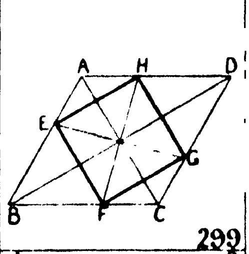

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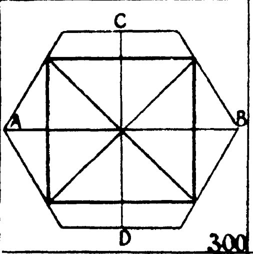

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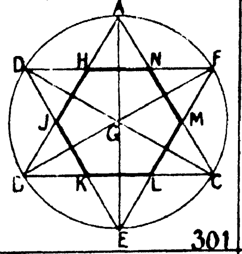

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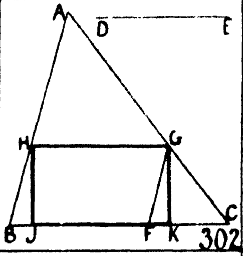

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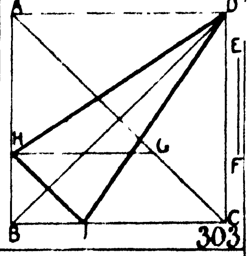

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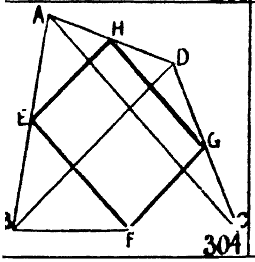

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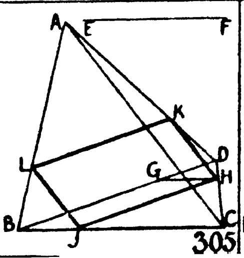

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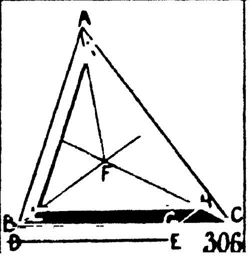

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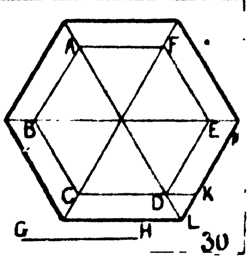

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INSCRIBED AND CIRCUMSCRIBING FIGURES

AE, *BF*, and *CD*. With centre *G* and radius *GA* describe a circle. Draw *DE*, *EF*, and *FD*. Then *HJKLMN* is the hexagon required.

302. WITHIN A GIVEN TRIANGLE *ABC*, TO INSCRIBE A RECTANGLE, THE LENGTH OF ONE SIDE, *DE*, BEING GIVEN. Set off *BF* equal to *DE*. Draw *FG* parallel to *BA*. From *G* draw *GH* parallel to *CB*. Draw *HJ* and *GK* perpendicular to *BC*.

303. IN A GIVEN SQUARE *ABCD*, TO INSCRIBE AN ISOSCELES TRIANGLE, THE BASE *EF* BEING GIVEN. Draw the diagonals *AC* and *BD* of the given square, and on *CA* set off *CG* equal to the given base *EF*. Draw *GH* parallel to *CB* and *HJ* parallel to *GC*. Draw *DH* and *DJ*.

304. WITHIN ANY GIVEN QUADRILATERAL *ABCD*, TO INSCRIBE A PARALLELOGRAM, HAVING GIVEN THE POSITION, *E*, OF ONE ANGLE. Draw the diagonals *AC*, *BD*. Draw *EF* parallel to *AC*, *EH* and *FG* parallel to *BD*. Join *G* and *H*. Then *EFGH* will be the required parallelogram.

305. WITHIN ANY GIVEN QUADRILATERAL *ABCD*, TO INSCRIBE A PARALLELOGRAM, HAVING GIVEN *EF*, THE LENGTH OF ONE SIDE. Draw the diagonals *AC*, *BD*. On one of them set off *BG* equal to *EF*. From *G* draw *GH* parallel to *BC*. Draw *HJ* parallel to *DB*, *HK* and *JL* parallel to *CA*. Join *KL*. The same method may be used for inscribing a rectangle in a square, rhombus, or trapezoid.

306. WITHIN A GIVEN TRIANGLE *ABC* OR ANY REGULAR POLYGON, TO INSCRIBE ANOTHER SIMILAR FIGURE, HAVING ITS SIDES PARALLEL TO AND EQUIDISTANT FROM THOSE OF THE GIVEN FIGURE, THE LENGTH OF ONE SIDE, *DE*, BEING GIVEN. Bisect the angles and obtain the centre *F*. Set off *BG* equal to *DE*. Draw *GH* parallel to *BF*, *HK* parallel to *CA*, *HL* parallel to *GB*, and join *K* and *L*. Then *HLK* is the required triangle.

307. ABOUT A GIVEN TRIANGLE OR ANY REGULAR POLYGON (SAY A HEXAGON *ABCDEF*), TO DESCRIBE ANOTHER SIMILAR FIGURE, HAVING ITS SIDES PARALLEL TO AND EQUIDISTANT FROM THOSE OF THE GIVEN FIGURE, THE LENGTH, *GH*, OF ONE SIDE BEING GIVEN. Find the centre as before, and produce the lines bisecting the angles. Produce *CD*, and set off *CK* equal to *GH*. Through *K* draw *LM* parallel to *DE*, and the other sides parallel to the respective sides of the given hexagon, as shown.

OBJECT DRAWING

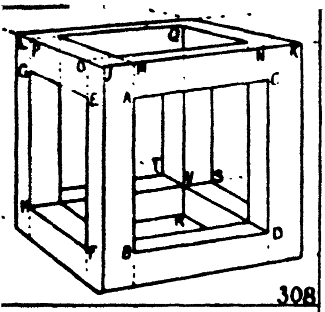
Skeleton Cube. To many students the skeleton cube seems to be a very difficult object to draw correctly, and perhaps it is so, especially when it is in positions similar to that shown in **310**; but most, if not all, the difficulties will be overcome, if sufficient care is given to the preliminary but thorough analysis and observation of the model, before drawing a single line. For example, it will be seen that the edges may be divided into *three* sets—viz., first, a *vertical* set, secondly, all those vanishing to the *right*, and thirdly, those receding to the *left*, as in **308**. In **309** there are vertical and horizontal sets, with a third set receding straight away in front from the spectator. In **310** will be seen a set vanishing upwards to the right, another upwards to the left, and a third set downwards to the right. The above examination of the object ought to enable the student to make no errors in the direction and apparent convergence of receding parallel edges. Begin by drawing the appearance of the object as if it were a solid cube, as shown in small sketches in **309**, being very careful to keep the true relative apparent proportions between the different faces. Next, having noticed the proportion of the apparent thickness of the bars, sketch the vertical lines *AB*, *CD*, *EF*, and *GH*, which represent the bars of the vertical visible faces and then the lines *AC*, *BD*, *EG*, and *FH*, for the receding edges of the same faces. The top surface is then easily obtained by producing the vertical edges *BA*, *DC*, *FE*, and *HG*, to the top front receding edges *JK* and *JL*, and from the points *M*, *N*, *O*, and *P*, draw lines converging right and left with *JK* and *JL* in **308**. The next step is an important one, and that is drawing accurately the position of the edges *QR*, *HS* and *DT*, which should all intersect at *one* point *V*. If they do not do so, then the student may be certain that he has made a mistake previously in the convergence of the other edges, or the proportion of the faces. The rest of the drawing should be found very simple, especially if the student will notice the connection between the various edges as shown by dotted lines. In **309** will be seen an instance of very much foreshortening of the thickness of the inner surfaces of the bars; this will need special care. We must not forget that the edges *AB* and *CD* should appear to converge to the same point as the edges which recede at the top. The observer is supposed to be opposite the front vertical face of the cube, which is below the eye level. When the cube is tilted, as shown in **310**, we have a somewhat more difficult view to draw, but method and

will overcome the difficultie

the position of the nearest corner *A*, then the direction of the three lines radiating from it. Each of these lines belongs to a different set, and all others depend upon them for correctness in every respect, therefore great care should be given to deciding their apparent direction and length. The rest of the drawing is then as easy as in **308**, for the student has only to obey the rule of apparent convergence of receding parallel edges, and observe their relative proportions.

Vases. The vases chosen for models in this course are those to be found in all art schools, but other vases will do just as well for examples to study. Fig. **311** is a view of the vase known as the white bottle, **312** as the terra-cotta vase, and **313** as the red glazed one, all standing, of course, in a vertical position.

Beautiful Form of the Vases. The student should observe the great beauty of these vases, which is shown in the harmonious proportions between the various parts, and the subtle but charming and beautiful curves of the contour lines, etc. When the student perceives



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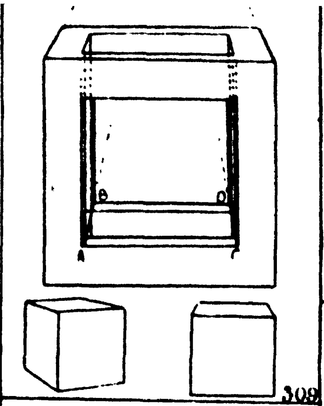

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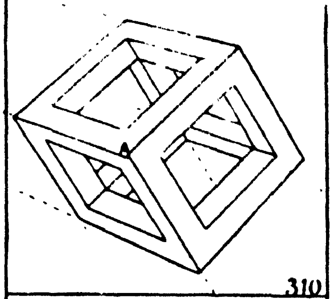

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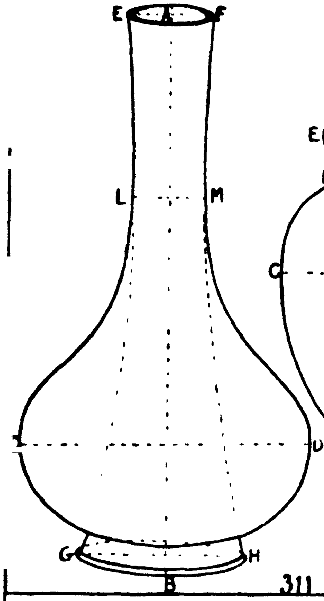

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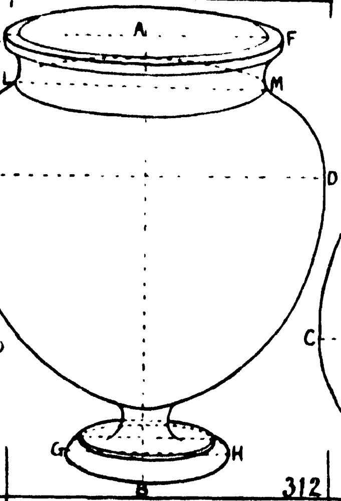

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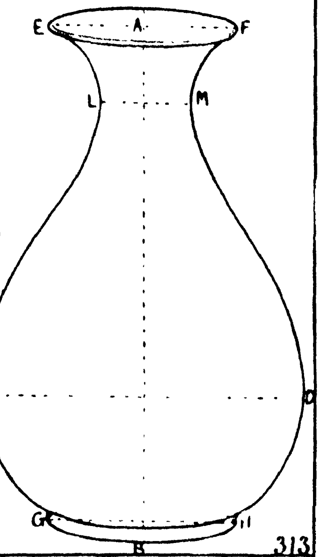

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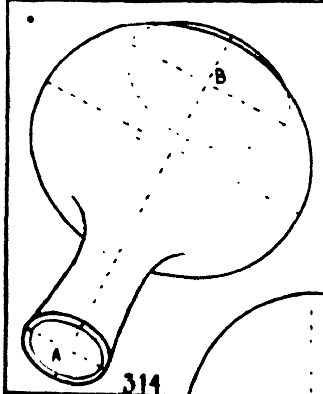

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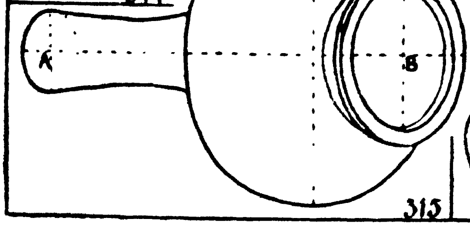

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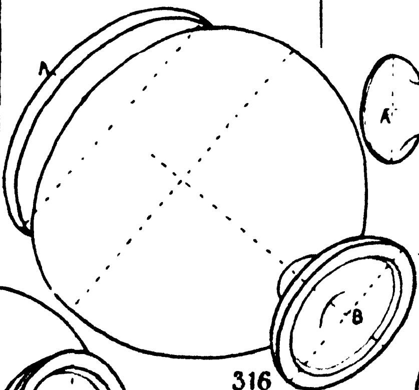

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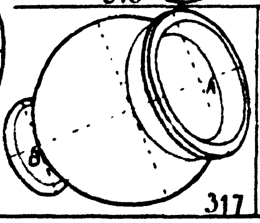

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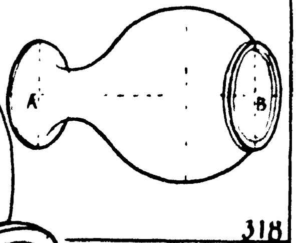

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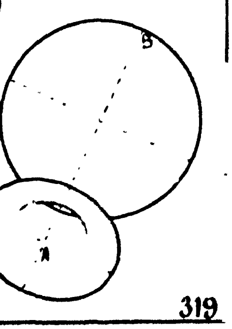

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LESSONS ON THE SKELETON CUBE AND VASES

the beautiful form of these objects he will not be likely to make a wrong and ugly drawing of them, as is too often done by unobservant, inappreciative, and careless beginners.

Method of Drawing Vases. When the vases are symmetrical in form and standing in a vertical position, as in **311-313**, begin by sketching the upright axis *AB* of the vase; then determine the greatest width, both as regards position and proportion, and draw the line *CD* to represent them, noticing carefully that it *appears at right angles to the axis AB of the object*. Next draw the major axes of the various ellipses, such as *EF*, *GH*, etc., again observing that the axes are always perpendicular to *AB*, and then fix the position of the narrowest part of the neck, such as *LM*. Now proceed to sketch the main contour lines and the curves for the ellipses, all the time endeavouring to realise the beautiful form of the vase, which sometimes requires the line to curve slowly and at others more quickly. Great attention should be given to the rims, bases, and mouldings, if any, observing the apparently greater width of the rim at the ends of the major axis, as in **312**. Notice the apparent connection (shown by dotted curved lines in **311**) between the neck and the base; the *elliptical* form of the body in **311**, the *oval* form of that in **312**, and the *circular* or *globular* shape in **313**. Do not make the very common error of drawing a horizontal straight line for the bases, for as these are really circular in shape and below the eye level, they must appear as parts of ellipses. The base can appear as a straight line, only when it is exactly level with the eye, and, if lying in an oblique position, when the *plane of the base* would pass directly through the observer's eyes.

Oblique Positions of Vases. These positions often cause great trouble to beginners, but very little should be experienced if the student will first of all draw the correct direction and length of the axis *AB* of the vase; and observe that the greatest width, the narrowest part of the neck, and the major axes of the ellipses are *always at right angles to the axis AB of the object*. The student should place the vases in such positions as shown in **314-319**, and verify the above laws. In these oblique positions of the vases, peculiar appearances of the rims, interiors, and bases will be noticed, and much careful observation will be necessary for the mind to perceive them. All the representations in **314-319** are those of the vases lying down *on a horizontal plane*, sometimes with the mouth, at others the base, towards the spectator. Figs. **315** and **318** are of special interest, for they are splendid views for finding out whether the student will draw what he *sees*, instead of what he *knows*. As stated before, the vases are lying *on a horizontal plane*, with the axis of the objects really slanting downwards away from the observer, yet this axis in each view shown in **315** and **318** *appears horizontal*; but it must be remembered that this is only so when the vase is turned away at *a particular angle*, for it is quite possible to have the axis of the object—when its base is towards the observer—apparently slanting downwards or upwards, and the student should make experiments with the vases in various positions.

General Observations. The student has now had all the main principles of object drawing explained to him, and the more practice he gets, the more he will find how often these principles are employed and what sure guides they are to the correct drawing of any object he may wish to represent. But he should not stop here, for there is still much to be done, and of much more interest, when light and shade and colour are involved. Yet tone and colour will not hide bad drawing—rather, they will emphasise it; therefore, it is most necessary to *learn to draw correctly*, which can only be accomplished by continual and regular practice. The student should carry a sketchbook and draw in it as often as he possibly can any object of interest that presents itself. If he cannot join an art school he should obtain criticisms and advice on his work from some friend who can draw, and should not be discouraged because his work may perhaps be adversely criticised, but, rather, he should be spurred on to do much better work.

MEMORY DRAWING

This is, without doubt, one of the most important branches of drawing, and should be cultivated as early as possible. It is a powerful stimulus to the imagination, besides being a means of cultivating confidence and self-reliance in the student. It has been said: "A visual image is the most perfect form of mental representation wherever the shapes, positions, and relations of objects in space are concerned. It is important in every handicraft. The best workmen are those who visualise the whole of what they are going to do before they take a tool in their hands."

Method of Procedure. To make true progress in this subject, as in all others, method is required. The student should begin by placing at a convenient distance and level some simple rectangular object, such as a box, book, stool, table or either of the rectilineal geometrical models used in object drawing, and make a most careful observation concerning their apparent general proportion and direction of receding edges, and not forget the important rule: "Draw what you see and not what you know." It is most essential that these main facts should be observed correctly and then the details will give little trouble. These observations may be finished in three or four minutes. Having marked the position of the object, so that it may be again placed in exactly the same position, remove the object from sight, and then make a fair-sized drawing of it from memory. Now replace the object in its former position and compare the drawing with it. The same procedure may be adopted with regard to curved and more difficult objects, such as a cup and saucer, a silk hat, etc. The student should practise regularly, and eventually he will be able to draw with ease from memory, flowers, plants, and even animals.

Continued

BILLS OF EXCHANGE

Advantages of Bills of Exchange. Distinction between Salaries and Wages. Dishonoured Bills. The Parties to a Bill

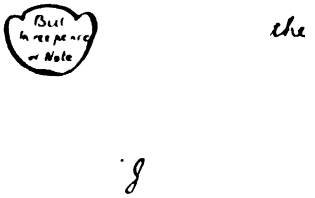
Continued from page 979

By A. J. WINDUS

Bills of Exchange. Transaction (*i*), September 22nd. Drew on J. Wake for £20 10s. 6d., at three months' date, in settlement of account to 19th September.

Strictly speaking, this is not a transaction, because there are not yet two parties to it. It has, however, been placed here as a convenient peg on which to hang a few remarks about bills of exchange, in order that we may the better understand transaction (*n*).

Paraphrasing (*i*), we might say that up to September 19th, J. Wake owed Bevan & Kirk £20 10s. 6d. For reasons not given, Bevan & Kirk desire to obtain written acknowledgment of the debt in a peculiar form called a bill of exchange. They therefore "draw" on Wake for the amount ; that is to say, they send him a written demand couched in the following terms :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The above document is written on stamped paper. The cost of the stamp varies with the amount of the bill, as follows :

	Not over £5	1d.
Over £5	,, ,, £10	2d.
£10	,, ,, £25	3d.
£25	,, ,, £50	6d.
£50	,, ,, £75	9d.
£75	,, ,, £100	1s.
£100	One shilling per cent., and an extra shilling for any odd amount, thus a bill for £542 would carry a six-shilling stamp.	

The foregoing stamps are not adhesive, as postage stamps are, but are impressed beforehand on the paper on which bills and promissory notes are to be written. The work of stamping the paper is performed by the staff of the Inland Revenue Department, and stocks of bill paper, bearing stamps of various denominations, are issued to different post-offices throughout the kingdom, and to law stationers and others for sale to the public.

There is, however, an exception to these stamp duties in the case of certain bills. Any bill of exchange, no matter how large its amount, which is either payable on demand, or at sight, or on presentation, or within three days after date or sight, is allowed to escape with a nominal stamp-tax of one penny. That is why cheques, which, legally, are nothing else but bills of exchange drawn on a banker, payable on demand, are allowed to issue bearing penny Revenue stamps only. Not very long ago a Chancellor of the Exchequer tried hard to increase the tax on cheques to twopence for each cheque drawn, but business men and bankers manifested such determined opposition to the proposal that it was withdrawn.

Advantages of Bills. We are not told why Bevan & Kirk drew on Mr. Wake for the amount of this debt, but if we consider three of the reasons for creating bills of exchange, we may perhaps find that all three would apply in this instance :

1. A bill of exchange is a negotiable instrument.
2. It fixes beyond dispute the amount of the debt.
3. If dishonoured, it confers upon the holder a right of action, based upon the instrument itself.

The legal doctrine of negotiability has a far-reaching influence in commerce. For its fuller treatment the student is referred to the section on Commercial Law [see Law], but its practical effect will be noted in transaction (*n*) to follow.

With regard to the second and third points, the law presumes, until the contrary is proved, that all bills of exchange are given for value received, whether the phrase "value received" is present or not. In other words, a bill of exchange presupposes an existing debt on which the bill is founded. In the case before us, the pre-existing debt was one of £20 10s. 6d. due by J. Wake to Bevan & Kirk.

Spurious and Dishonoured Bills. Sometimes false or spurious bills, which are not founded on a prior debt, are created. These are known as *kites*, or accommodation bills. Frequently there is nothing whatever to distinguish them from genuine bills, and it is therefore an essential rule of law to put all bills upon an equal footing. Moreover, in the absence of any unusual circumstance, the law does not regard the question whether adequate consideration has or has not been given for a particular bill. For example: if Wake "accepted" the bill drawn on him by Bevan & Kirk—that is, if by signing his name across the face of the bill he promised to pay it at the due date, he could not afterwards refuse to pay it on the plea that he had since discovered moth in some of the articles he had bought from Bevan & Kirk. Therefore, we may say that a bill of exchange fixes beyond dispute the amount of the debt. Again, if, having accepted the bill, Wake dishonoured it by non-payment of the amount when it was due, the holder (not necessarily Bevan & Kirk) could sue on the bill alone for the full amount, plus the law costs. The law requires no further evidence of indebtedness than is supplied by the bill itself, and thus there would be no need to go to the trouble of proving delivery of the goods or their sound condition at the time when Wake's order was executed.

The Parties to a Bill. While there are three parties to a foreign bill, there are generally only two original parties to an inland bill—to one, that is to say, which is both drawn and payable within the British Isles. In Wake's bill, the two parties are apparently Bevan & Kirk, drawer, and J. Wake, drawee. But up to now we have no right to apply the term "party" to J. Wake, except in the sense of his being a passive or an involuntary party. Consequently, it is not until he becomes an active, or a consenting party, by accepting the bill drawn upon him, that we have a real transaction capable of being expressed in terms of double-entry. Accordingly no entry of (*i*) can be made in the books of account, although a copy of the letter which was sent to J. Wake covering the draft for acceptance, will be found in the counting-house letter book.

We pass on to the next:

> Transaction (*j*), Sept. 23rd. Paid salaries and wages as per salary book, £11 9s. 0d.

In a former paragraph it was stated that most of the staff of Bevan & Kirk were paid weekly. The junior partner personally attends to this matter. Every week he makes out, in a private memorandum book, a list of the weekly employés, placing opposite each name the amount due as salary or wages. The total being ascertained, the exact sum is drawn from petty cash and distributed by the junior partner. The memorandum book spoken of has been noticed under the name of salary book in our list of supplementary records. To assist those of an inquiring turn of mind in stifling their natural curiosity, the junior partner keeps this book locked up in his desk, and the weekly totals merely are entered as payments in the petty cash book (*q.v.*).

Distinction Between Salaries and Wages. There is a technical difference in meaning between the terms "salaries" and "wages" which merits a brief consideration. Let us suppose that the weekly total of £11 9s. 0d. for salaries and wages is made up as follows:

SALARIES.			
2 town travellers	6	0	0
Stockkeeper	1	1	0
Junior clerk		17	6
2 boys	1	1	0
	8	19	6
WAGES.			
3 girls	2	9	6
Total	£11	9	0

The broad distinction to be observed here is that *wages* relate to expenses of production (or buying), and *salaries* to expenses of distribution (or selling). Wages are expended either in manufacturing goods or in making them merchantable. Thus, the girls employed by Bevan & Kirk are engaged in assorting, under special selling or "call" numbers all goods received, repacking them in smaller quantities suitable for Bevan & Kirk's class of business, and so on. Their wages, therefore, are reckoned as addition to the cost of the purchases. The other weekly wages, whether "productive," as in the case of the town travellers, or "non-productive," as in the case of the junior clerk, are styled salaries, and treated as part of the fixed or establishment expenses of the firm.

> Transaction (*k*), Sept. 23rd. Paid Rice & Sons cheque, value £49 4s. 3d., in settlement of their account, £50 9s. 6d., less 2½ % discount

This transaction is the converse of (*h*), in which Bevan & Kirk *received* cash and allowed discount, whereas here Bevan & Kirk *pay* cash and obtain discount. Since the firm avail themselves of discount terms as often as possible, it will be convenient to have a column ruled on the right-hand side of the cash book on purpose to accommodate items of discount obtained. Each item is entered in a line with the cash item to which it relates. Thus, Bevan & Kirk paid away £49 4s. 3d to Rice & Sons in settlement of an account of £50 9s. 6d.—that is, they deducted £1 5s. 3d. discount, being 2½ % on the latter amount. As the cheque represents a payment made by Bevan & Kirk, the value of it is entered on the payment, or credit, or right-hand side of the cash book; and in a line therewith, on the same side, discount £1 5s. 3d. is entered in the discount column.

> Transaction (*l*), Sept 25th. Paid postage of parcel to Williams Bros., Cape Town, 5s.

It is usual to make such payments out of petty cash, and we shall accordingly expect to find this entered under the proper date in the payment column of the petty cash book (*q.v.*).

Continued

NURSE & GENERAL SERVANT

Duties and Daily Routine of the General Servant. The Cook-General. The Sewing-maid. Nurse and Under-nurse. The Daily Servant

Continued from page 1005

By A. EUNICE T. BIGGS

THE GENERAL SERVANT

The duties of a general servant are so numerous that unless she is very energetic and industrious she will find every moment of her day almost too fully occupied. She should be very strong, healthy, and active. If she is inclined to waste her time, or to be unwilling over her work, her duties will become very arduous. The work of a general servant is undoubtedly hard, but no harder in a small household than the work of another servant where there is a large family. She will, in all probability, be greatly assisted by the mistress of the house, and by the grown-up daughters, should there be any. The mistress will probably be down a good time before breakfast, making the tea, etc., and generally helping the maid to be punctual with the meal. Then, after breakfast, the former will probably assist with the making of the beds and the dusting. The drawing-room will be undertaken by the mistress or a grown-up daughter, both in order to lighten the servant's duties, and also because the furniture and the ornaments of a drawing-room need gentle handling. The rough work of a general servant naturally tends to make her hands less fit for such employment.

Morning Duties. The general servant should rise early in order to get through some of her work before the family are about the house. She should light her kitchen fire directly she comes downstairs, clean the hearth, rub up the range, and put the kettle on to boil for the breakfast.

She should then go to the dining-room and breakfast-room. After opening the windows, she should well sweep the carpet. If she is allowed the use of a roller-sweeper this will save much labour. Sweeping with a broom will then only be necessary from time to time.

She should remove the rug from the front of the fireplace, spread a large coarse drugget over the carpet, and proceed to remove the ashes, clean the hearth, and lay the fire. The tiles should be wiped over with a damp cloth, and the bars of the grate polished. The work of the general servant is considerably lightened in the summer when she has only the kitchen fire to re-lay. Fires make a good deal of dust and dirt, so that the rooms will need still more careful cleaning during the cold months of the year.

Breakfast. Having laid and lighted the fire, swept the carpet, and dusted the room, the servant should lay the table for breakfast. At the appointed time she will call the family, taking up hot water if required to do so. She should then clean such boots as will be wanted early, afterwards tidying herself before beginning her further duties. If the family breakfast late, she may find time to tidy up the drawing-room grate, clean the doorsteps, wash the hall, and sweep down the stairs before breakfast. In any case, these duties are next in her daily routine.

The general servant must endeavour to be methodical in her work, and to remember the many little details that add so perceptibly to the comfort of the family. For example, she should put the plates and breakfast dishes into the oven to heat in good time, so that they may be ready for breakfast. Then she will set about the preparation of the meal so that it may be served punctually.

After-breakfast Duties. This done she should take her own, which will not take very long; and while the family are finishing she should go up to the bed-rooms and strip the beds for airing.

The family will do well to be considerate in the matter of sitting long over breakfast. If the meal is unduly prolonged by unpunctuality or by thoughtlessness, it will throw out the servant's work and make her daily routine laborious.

Whilst the beds are airing, the servant should clear away and wash up the breakfast things. In this she will probably be assisted by her mistress if the family is numerous. The servant should then rearrange the kitchen, sweeping up the crumbs that have fallen on the floor during the preparation of breakfast, and putting away all utensils not in immediate use.

The mistress will then come into the kitchen and give her orders for the day. She will visit the larder and arrange with the servant as to the various meals to be served. In a small household the mistress will herself take active part in the cooking. Good food, tastefully prepared, and well cooked, is a great factor in the preservation of health, and on the health of the individual members depends not only the comfort, but also the prosperity of the family.

Daily Routine. Having received her orders for the day, the general servant returns to the bed-rooms. Either alone, or more usually with assistance, she makes the various beds. She then arranges the washstands, goes over the carpets with a roller or dustpan and brush, and finally dusts the furniture. This dusting is often consigned to a daughter of the house, and in many families, where there are grown-up daughters and only moderate means, each girl makes her own bed and dusts her own room. This considerably lightens the general servant's burden, and enables her to devote her energies to work from which it would be less easy to relieve her.

Having finished her routine work upstairs, the general servant will probably have some particular task to perform. For example, each bed-room must be "turned out" at regular intervals, either once a week or once a fortnight. Then the stair-rods will need carefully rubbing with polishing paste and leather, and in some houses a certain amount of washing has to be done at home. In most cases help from outside is occasionally hired by the mistress for particular parts of the work. For example, in turning out rooms and in washing, she will find extra help essential if the wheels of the household are to run smoothly. The hands of the general servant are often already so full that she cannot be responsible for further duties.

Preparation and Serving of the Mid-day Meal. After her morning's work, the general servant should wash her hands and put on a clean apron before laying the cloth for the mid-day meal. She should then put everything in readiness on the table and serve the food at the appointed time. She may either take her meal concurrently with, or after, that of the family. In the former case, she waits at table till all are served, and then goes to the kitchen for her own dinner. When the dining-room bell rings, she should answer it at once, remove the plates and dishes of the first course, and bring in the pudding. In houses where a general servant only is kept, the dinner will be served at mid-day.

When the meal is over, she should clear the table, dust and tidy the dining-room, re-make the fire, and brush up the hearth.

Afternoon Duties. Having finished her own meal, and rearranged the dining-room, the general servant must wash up the things used at dinner and during its preparation. Plenty of boiling water and soda will lighten her task. She then goes up to her room, changes her print dress for a black one, puts on a muslin apron and clean cap, and returns to the kitchen. If she is a quick girl, she will find herself free to sit down and sew for a short time before tea. After this little rest she will prepare and take in the tea, and then again her time will be unoccupied. Some afternoons she may devote to polishing the plate or brasses, others to turning out her kitchen cupboards and re-arranging them, or she may sew either for herself or for her mistress.

Evening Work. Tea being finished, the general servant should arrange the bed-rooms. She should close the windows—at any rate, partially—draw down the blinds, close the curtains, and see that dirty boots and shoes are taken away from the rooms. Lamps or gas should be lighted at dusk and passage windows closed.

If the family partake of an early tea, supper will be served during the evening. The meal will probably be of a simple character, not necessitating any cooking. After clearing it away, the general servant will have a certain amount of washing-up to do; she should then get everything in readiness for the night, and make certain preparations for the morning. She may put the breakfast china in readiness, being careful to cover the tray to protect it from dust, and she should see that there is a plentiful supply of coal, dry sticks, and paper for her fire-lighting operations of the next day.

THE COOK-GENERAL

Where two or three servants are kept, and the kitchen work is undertaken by one servant only, she is designated a cook-general. Not only is the cooking assigned to her, but various items of housework also. She is responsible for all the work of the kitchen, unassisted by a kitchen-maid, so she must keep the kitchen and scullery clean, wash up all cooking utensils, and polish up the copper and tin vessels and covers. The hall, stairs, and dining-room, or breakfast-room will doubtless be placed under her care; for these rooms she will be responsible. In small establishments the whole of the housework is often divided between a cook-general and a house-parlourmaid, the care of the bed-rooms and drawing-room, and the preparation for meals being undertaken by the house-parlourmaid, while the cooking and the care of kitchen, hall, and sitting-room are reserved for the cook-general.

THE SEWING-MAID

The sewing-maid is oftenest found in families where there are many young ladies, and where means are moderate. As the children grow beyond the age at which the services of a nurse are indispensable, the mother finds that some responsible person is necessary to help to keep their wardrobes in good order and repair. Perhaps the family income does not warrant the engagement of a lady's-maid, and a sewing-maid's services are therefore requisitioned.

Duties of the Sewing-maid. The sewing-maid will, to a certain extent, in such households, supplement the services of the house-maid. She will call the young ladies under her care in the morning, bringing in their hot water and drawing aside the bed-room curtains. She will, if required, help them when dressing. She may help with the process of hair-brushing and dressing, and with the fastening of frocks and blouses. The duties of the sewing-maid will vary widely in different classes of households. In most cases she acts as young ladies' or children's maid. Her privileges are not those of the lady's-maid, but her duties consist, like those of the maid, in personal attendance on the young ladies of the family. Occasionally, the sewing-maid may wait on the lady of the house instead of on the daughters.

Daily Work. The greater part of the day the sewing-maid will be busy with her needle. She should be very skilful in plain sewing, able to cut out and make all kinds of underwear, and having some knowledge of dress-making, in order to make simple clothes for her young mistresses. She should have good taste, and be able, if asked to do so, to give advice when new dresses and blouses are being purchased.

A sewing-maid should be handy and clever in contriving and renovating. By this means she will save her mistress much expense by enabling her to use up garments that might otherwise have to be discarded. By turning and patching, and by skilful adaptation, the best is made of every article of clothing. In a large family of girls the dressmaker's bill can be surprisingly curtailed by the ingenuity of a clever sewing-maid. She should study fashion books and papers, and try to keep her ideas up to date.

All her work should be neat and painstaking; she will, no doubt, find that the ladies for whom she works will themselves take an interest in her sewing. She will then let them help the work as much as possible, and if at first this means a little delay, it is worth the extra trouble. They will soon get into the way of such work and give much valuable help.

The sewing-maid's chief difficulty will be fitting; but if she has been taught her work well, she will be able to adapt her knowledge to the task in hand, and to obtain really satisfactory results. Unless asked to do so, the sewing-maid should refrain from giving advice on matters of dress, but when asked her ideas, she should state them fearlessly, and with a genuine wish to help her mistress.

THE NURSE

The position of head-nurse is one of great importance. She is responsible for the general arrangement of the nurseries, which are entirely under her care; she should, therefore, be a thoroughly sensible and trustworthy woman, who realises how much the character and development of her little charges depend on her efforts. The youngest child in the nursery will be her special charge. After the departure of the monthly nurse she will undertake the care of the infant, washing and dressing it, taking it into the open air and watching over its sleeping hours. She should, from the very first, endeavour to inculcate good habits in the child; these are easily formed by quite a tiny baby, and the lessons learned are seldom forgotten in later development.

Characteristics of a Good Nurse. A good nurse should have unlimited patience and sweet temper. Irritable manners and harshness should find no place in the nursery; they tend to make the children cross, and even untruthful. In the daily training of the children the nurse should watch for the earliest indication of individual characteristics. By her own influence she should make them feel the charm of unselfishness, gentleness, and perseverance.

In her personal appearance and habits the nurse should be invariably neat and clean. Her work is light and never menial, so she will have no excuse for dirty aprons and soiled hands. Of course the nursery routine will, to a certain extent, disarrange her dress, but she should endeavour to make herself tidy again as soon as possible.

A good nurse will always insist on implicit obedience, even from the tiniest child; but she will be very careful in telling the child what is to be done, and will never allow herself to become tyrannical.

Good order should reign in the nursery. Little children dislike confusion and misrule, and are made thoroughly uncomfortable by it. Good discipline does not necessarily mean severity, and the utmost gentleness and kindness are compatible with orderliness and obedience.

The nurse generally takes her meals in the nursery with the children, if she works single-handed, or afterwards if there are nursemaids working under her. Sometimes she may take her meals in the housekeeper's room, if she can leave her young charges in safe hands. The nurse should be clever with her needle, for she will have many hours which can be profitably spent sewing for her mistress or for the small inhabitants of the nursery.

THE UNDER-NURSE

One or more under-nurses will be kept, according to the number of children, and according also to the establishment. The under-nurse will clean the nurseries, scrub the floors, sweep, dust, and light the fires; and in every way she should endeavour to keep the nurseries neat and cheerful. She will carry up the nursery meals and clear them away; and under the supervision of the head-nurse she will be responsible for the dressing of the older children. Her spare time will be spent with her needle.

THE SINGLE NURSE

In a small establishment, where only one nurse is kept, her whole time will be occupied with her little charges. She will probably be assisted in her work by her mistress, who will endeavour to relieve her of the children for a few hours every day, in order that she may get the necessary rest and recreation. In most cases the nurse's outdoor exercise is assured, for she has to take her little charges for walks, and at the same time her own health benefits by the time spent in the open air. It is also important that the nurse should be allowed time to associate with her fellow servants. The greater part of the day will be spent with little children, who may be very sweet and lovable, but at the same time may be hardly old enough to be really companionable. Thus it becomes necessary for the nurse's own comfort that she should be given time to talk with the other maidservants, and become friendly with them.

Assistance with Nursery Work. The single-handed nursemaid will probably need some assistance with the rougher parts of the nursery work. Either the general servant or the housemaid will help to keep the nurseries clean, scrubbing the floors, laying the fires, and bringing the meals up from the kitchen. The exact organisation of the work should rest with the mistress, and she should do all in her power to let each maid know quite definitely what work she is expected to do. In this way little difficulties which might arise are smoothed over, and each servant can perform her work satisfactorily.

Nursery Meals and Medicine. The times of the nursery meals should be arranged by the mistress, and the food prepared should be ordered by her. The nurse should not allow constant eating and drinking between meals, and should discourage excessive sweet-eating.

In the matter of health, the nurse should be on the alert to detect symptoms of disease of any kind. She should at once inform her mistress of any important sign, and should never presume to dose the children herself, but act only under the doctor's orders.

THE CHARWOMAN

The duties of charwomen vary more widely, perhaps, than those of any other servant. Many charwomen merely act as cleaners, and work for a fixed weekly wage for a certain number of hours every day. Their duties in this case consist of sweeping, cleaning, and dusting rooms, scrubbing floors, and lighting fires in cold weather. Such women always provide their own food, and in many cases one woman may take the responsibility for several sets of offices.

The duties of the charwoman who goes to work in a private family also differ widely. In the generality of cases her work will supplement that of the ordinary domestic servant. Many mistresses arrange for a woman to come in once or twice a week to help with any special cleaning that has to be done. She will be called in to do the roughest household work, such as beating mats, and all kinds of rough cleaning

The actual wages earned by the charwoman will entirely depend on the locality in which she works. She is generally paid by the hour or day, at the rate, in a town, of about 2s. to 2s. 6d. the day. The hours at which the charwoman is expected to arrive and depart should be clearly stated at the time she is engaged.

Desirable Characteristics. The most efficient charwoman is the middle-aged married woman who was a domestic servant before her marriage. She will then be experienced in domestic matters and the routine of a house, and be more capable of doing useful work. The charwoman's temptations are many, so her honesty should be unimpeachable. She should be punctual, neat in appearance, clean in the execution of her duties, and very thorough and painstaking

THE DAILY SERVANT

In towns, where rents are high, and the expense of an extra bed-room are matters for careful consideration, many people find it desirable to engage a "daily" servant. In a small family living in a flat a daily servant is commonly engaged, the limited space in the flat making this arrangement more convenient.

The duties of the daily servant will, in this case, be those of a "general," except that, as the flat is generally small and the rooms fewer in number than in an ordinary house, her duties will be less arduous

Her wages will be correspondingly higher than those of a servant living in, for though her board is provided, she has to make her own arrangements for lodging. It is impossible to state any fixed wage, since the rate of payment varies so widely; but the average wage is from 7s to 10s per week.

CYCLOPAEDIA OF SHOPKEEPING

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SHOPKEEPING

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BARBERS

In these days there seem to be objections to the use of the good old word barber. It is difficult to know why. For both etymological and historical reasons it is a good expressive word. Shakespeare uses it, and the Company of Barber-surgeons claims incorporation from the year 1461, although about a century later barbers were relieved of the duties of drawing teeth and letting blood, and restricted to the humble sphere to which they confine their craft to-day. The plea for calling a spade a spade urges that a man who operates on the beard should be designated a barber. Having made this protest, we kowtow to public and trade prejudice, and refer readers who would know something of the commercial side of barbering to the more genteel title "Hairdressers," later in this course.

BERLIN WOOL SHOPS

The name "Berlin wool shop," although still in general use, is somewhat of a misnomer nowadays, inasmuch as Berlin wool forms an insignificant feature in the equipment of a modern fancy-work or art needlework store. The stock-in-trade of such an establishment would include, in addition to all kinds of knitting and crochet wools and yarns, white goods, traced art linens and drawn-work, materials for ribbon-work, Russian cross-stitch, stencil-work, canvas-work, embroidery silks, yarns, "Lustrine," and filoselle, together with crochet cottons, transfers, lace-making requisites of various kinds, and the knitting and crocheting needles, tambour frames, wool-winders, etc., that are used by home-knitters.

Competition and Opportunity. Owing chiefly to the competition of the large drapery houses, each of which has its fancy-work department, the number of shops exclusively devoted to the sale of these goods is decreasing, so that this branch of shopkeeping would not at first appear to commend itself as a desirable speculation. Experience teaches, however, that shops of this kind, when managed by women who are themselves clever needlewomen and are competent to advise their customers, not only as to choice of designs or colours, but to show them the best methods of making up the materials sold and, if necessary, to commence the work, are in many ways superior to the large shops, where the assistants are frequently taken from other departments, and often have no practical knowledge as to the actual manipulation of the goods sold. Many customers prefer to deal with these special shops, and it will be a matter of regret if women allow to pass from their hands what is to many a congenial occupation as well as a means of livelihood. Moreover, it is a business in which very good profits are made.

Qualifications for Success. It must not, of course, be assumed that because a woman may be a skilful worker that therefore her success in business will be assured. The essential qualifications when opening a Berlin wool shop are a knowledge of bookkeeping and some experience of business methods, a capital of not less than £200, and a practical acquaintance with the work. To be a really efficient saleswoman it is desirable that the owner of the shop should serve an apprenticeship. But if this is not possible she should be assisted by someone who has been so trained; probably a daughter or younger sister would be chosen. Apprenticeship lasts from two to three years. As a rule no wages are paid during this period, and sometimes a premium is required. At the termination of her apprenticeship a girl can always find employment in the art needlework departments of the large stores, as there is an insufficient number of trained assistants to fill these vacancies.

The Start. A small shop in a populous neighbourhood should be selected, and the fittings would (like those in a baby-linen shop) consist merely of plain wood shelving, a glass case or two—a counter with glass top for preference—and in the shop and in the window several brackets, on which to display the goods. Although Berlin wools originally came from Berlin, and many still do so, the bulk of the wool sold is of English or Scotch manufacture. There are large woollen warehouses, or agencies, in London, Manchester, and various Midland centres for Berlin wools, merinos, and so forth, and Alloa and Greenock, in Scotland, are noted for their wools; while Welsh yarn is preferred by others. The beginner would lay in for an opening order, probably a dozen shades in Berlin wools (reds, blues, greys, etc.), but only in 1 lb. quantities. Scotch yarns are popular, and full of diversity in colours. The "heather mixtures" are innumerable, but a judicious selection of about 20 lb. of Scotch yarns would suffice; 6 lb. of Andalusian wool, and the same quantity of Shetland, should be enough, but it must be remembered that black and white should be secured in each case, and the colours made subsidiary and as select as possible, until the needs of the neighbourhood are determined. Then there is the "Lady Betty," a soft wool of varied thicknesses (two, three or four-ply), for making vests and other underwear;

2 lb. of each thickness would be wanted, and 6 lb. or so of fleecy wools (in white and plain colours). Of fancy wools (which are sold by the ball), one dozen balls would be needed of rabbit wools, and the same quantity of ice wools. These are not in plain thread like the others, but make up, in the case of ice wool, like astrachan, and with rabbit, like fur. Ostrich wool and Smyrna wool (for Oriental rugs) are likewise in favour. Then we come to knitting silks (speckled and plain), for dainty socks or for edging. These are in fast dyes of all colours, and Pearsall's silks are world-known. Of these, about 6 lb. would be required, in 1 oz. balls, four balls being required for a pair of gentleman's socks. Then there are embroidery silks of various kinds—twisted filoselle, filo floss, twisted flannel, and purse silks. These are sold in different colours and sets of shades. The purse silks are the most expensive, and filoselle and filo floss are used principally for embroidering chasubles, stoles, altar-cloths, and ecclesiastical vestments. The embroidery silks are sold in packets, and a careful selection of various colours is necessary. The same applies to embroidery cottons (white and ingrain)—which are sold in skeins—and to flourishing thread. An expenditure of £5 would give one a very fair selection of embroidery needles, knitting pins (bone, wood, vulcanite, and steel), crochet needles, rug needles, netting needles, and meshes (in wood and bone). In this category we might also place tambour frames, square frames (for working on), and wool-winders.

The Accessories. Besides the actual materials mentioned there ought to be a stock of articles for embroidery in silk or cotton, and either coloured or white. Among such are table-centres, duchess sets, nightdress cases, comb-bags, linen bags, antimacassars, tray-cloths, doyleys, and hem-stitched and drawn work. Also squares for cushions must not be forgotten. The same thing is obtainable in art serge, Roman satin (for sofa rugs, portières, etc.), pure satin, silk, or other fancy materials. These are usually bought ready-made, with fancy patterns on them. A few pairs of traced slippers, some canvas to be worked in wool, and tobacco-pouches, braces, shaving-cases, are all used for embroidery.

Then there are numbers of made-up goods, such as sofa-cushions, tea-cosies, egg-cosies, pincushions, and tidies, handkerchief and glove sachets (hand-painted on satin many of them), which might be stocked. A small stock should be laid in of such things as cushions covered with cretonne, pincushions, and other fancy articles for ladies' own mounting. Many linen articles are sold with the work started (sprays, flowers, monograms, etc.), to indicate how to proceed. It would likewise be well to include a supply of transfer patterns. These are used for ironing designs on linen or silk; nothing with a pile upon it like velvet can be transferred in this way. Books of designs are to be obtained. Of late years Teneriffe work has become very popular.

Credits and Prices. The same conditions regarding opening orders hold good in the Berlin wool trade as in drapery and its allied branches. A sure capital (though small) and good credentials will ensure ready acceptance of orders by any of the large wholesale houses, and much salutary advice regarding opening selections will be obtained from the accredited experts of the trade. The draper, of course, is cutting largely into the trade, and new openings, with a chance of full prices, are not frequent in large centres, and particularly in the metropolis. But even the large drapery houses look on the art needlework department as one of their best paying sections, and the average rate of profit is put at from 30 to 40 per cent. on wholesale prices. The selection of stock and the rate of profit charged would, as in all businesses, depend upon the neighbourhood. In some localities, for example, lace-making is the popular form of work, and in such cases materials for lace-making would be stocked in greater proportion, and prices would be proportionately less or greater, according to the amount of competition.

Methods of Cultivating Business. With a view to forming a connection, attractively drawn up circulars should be sent out in the neighbourhood, particularly to the mistresses of girls' schools and kindergartens, and to the members of church needlework guilds or Dorcas societies. The circulars should call attention to the fact that customers may receive instruction in the work if desired. If it be possible to form classes for teaching embroidery or any form of lace-making, etc., it will be found profitable to charge rather low fees for the tuition, as the primary object of such classes is to sell the materials used. Within the last few years the revival of embroidery as a trimming for ladies' dresses and blouses, and the great popularity of coarse crochet lace, especially Irish crochet, have created a fresh interest in both branches of industry, which at present are proving a profitable form of home employment to many.

In some country towns the owners of Berlin wool shops also keep a registry office for servants. This proves useful in bringing a number of people to the shop, which should be very tastefully arranged, with the novelties prominently displayed. The windows should be attractively dressed but not overcrowded. The saleswoman should keep herself well informed as to new fashions and fancies, particulars of which will be found in the art needlework journals, which should also be stocked and sold.

BOOKSELLERS

There are some trades which, though by no means extremely profitable to those who engage in them, have at least the advantage of being pleasant to pursue, and of these we may say that none is pleasanter than bookselling.

We have met booksellers who had better have taken to butchering or innkeeping, so ignorant and indifferent were they to the interesting features of their work, having, for instance, never heard of some well-known authors. We also know a librarian in charge of a great library, in a provincial city of half a million inhabitants, who was under the impression that Mr. Robert Barr was the author of "The Little Minister" and "A Window in Thrums." These are the round pegs in square holes, mentioned in the article on "The Choice of a Career," in the first part of the SELF-EDUCATOR, and we must not stay to consider them, but need only urge that no man who is not naturally fond of handling—not necessarily reading—books, and who is not interested in the names of authors and the works they have written, should contemplate for one moment the business of bookselling with any hope of succeeding therein.

The Bookseller's Assistant. As the beginning of every successful man is in some humble position in the trade in which he has made up his mind to excel, we begin with the bookseller's assistant rather than by describing how to start a bookselling business. Given the taste for books, a good memory, a bright address, hardly anyone who desires to become a bookseller need fail of the opportunity. There is no formal apprenticeship nowadays, and the conditions of employment will vary in every town, if not with every employer. In London, a youth will be taken on at 10s. or 12s. a week to learn the business, and in the course of five or six years—but largely according to the ability he displays—he will be accounted a fully-qualified assistant, his salary varying from 30s. to £2 a week. A chief assistant, where the proprietor is manager, will seldom get more than £3 a week, and £4 would be thought a good wage for one in charge of a considerable bookselling business. In the provinces a lower scale of wages is the rule: but, as living expenses are much less than in London, the remuneration is proportionately as good.

His Duties. The duties of the young assistant are at first limited chiefly to opening the parcels of books received from the wholesale houses, checking the invoices, and placing the books on the shelves or in the stock-room, according to his instructions. In London he will often have to go to the wholesale houses, or perhaps to the publishers, for books which have been specially ordered by customers. In the provinces there are also many large firms that confine their energies to the distribution of books and periodicals, though a good deal of correspondence is necessary in the case of provincial booksellers, as it is not always possible to secure an uncommon book from a local wholesale house, and it must then be ordered from London. The assistant who has an aptitude for lettering will be most useful to his employer, and we would advise young men, seriously aiming at success by making themselves of the greatest possible use to their employers, to go to the trouble of taking some lessons in designing, so that they may be able to write neat tickets for placing on the books in the windows. The bookseller who is alive to his business knows how much good may come from neat little cards with some special wording on them; not the same as every other bookseller may be showing, but something much more personal. We need not detail the other duties of the young assistant, which can be easily discharged by any youth of average intelligence; but of vital importance is the cultivation of the memory.

Use of the Memory. A bookseller's assistant who has a defective memory is a nuisance to everybody concerned, and ought to leave a business in which he can never hope to succeed. Why? Because, when a customer comes in and asks, let us say, for an edition of Chaucer without knowing quite which edition he wants, the assistant who can immediately tell him there is an edition at 3s. 6d., by the Oxford Press; the great edition by Professor Skeat, in six volumes at £4 16s.; and three volumes in the World's Classics, at 1s., and so on—the assistant who knows this is distinctly up to his business, and the one who does not know it without wasting the customer's time turning up catalogues, and fluttering about asking questions, is an incompetent. A course of memory training should be undergone by every ambitious assistant who is not naturally gifted with a "head for titles." We know men who seldom read books, and are in no sense to be regarded as persons of literary taste, yet there is hardly a book published within the last twenty-five years which they cannot tell you about – title, author, publisher, price, all are registered in their memories, and you have but to ask to be correctly informed. These are the ideal booksellers. The public don't want literary *opinions* from a bookseller—they want *information*.

Opinions and Knowledge. The latter quality the assistant can acquire by carefully and regularly following the trade papers, such as the "Publishers' Circular" or "The Athenæum," noting the names of all new books, and judging by the reviews whether they are likely to be in demand, and by what class of readers It is quite in order for an assistant to remark to a customer, "I notice this book is favourably reviewed in 'The Times,' it is greatly in demand"; but for him to say, "I have read this book and think it admirable," is generally an impertinence. The average assistant is not qualified to pass opinions on the books he sells, and nothing is more irritating to a person of cultured literary taste than to have some forward youth giving his ill-digested opinions on a work of literature. His business is to know where the book is, to get it instantly; or, if it is not in stock, to say how soon it can be supplied; to know the exact price, and not to be familiar in his conversation, but deferential.

The Bookseller. It is, of course, not easy to draw the line between the duties and qualifications of the assistant and those of the bookseller himself, as these merge into each other, and are entirely conditioned by the peculiar circumstances of each case. But we can best be of service by supposing that one who has been an assistant for a number of years contemplates starting for himself How will he go about it?

First he must know the terms on which books are obtained. Books are sent out from publishing houses at 33⅓ per cent. less than the published price, but the bookseller has always to pay *carriage*, and to those in the provinces this is a heavy item. Thus, a 6s. novel, which sells retail at 4s. 6d., is bought by the bookseller at 4s. 2d., thirteen being given as twelve. Different publishers have different tariffs, but this we may take as an average. So that, if a bookseller can dispose of thirteen copies of a new 6s. novel, he makes a profit of 8s. 6d., less the cost of carriage in the case of a country business, and the necessary shop expenses. There is a class of book which is far more profitable—"reprint" and juvenile literature. Such books are usually sold to the trade at half price, thirteen copies of a 1s. book, or an "assorted" 13 12, costing the retailer 6s., and realising 9s. 9d., which is better business than novel-selling, and involves less risk. Consequently, many booksellers look upon this class of book as their "bread-and-butter"; being always in demand, they can stock sufficient quantities to secure the full trade discount, and be assured that, sooner or later, they will dispose of the stock, whereas novels are always a lottery, and sometimes involve the venturesome bookseller in serious loss. It often happens that some novelist makes a great hit with a book, and the booksellers are tempted when that writer's next work is being "subscribed" to order a good quantity. It falls flat, and the booksellers are left with unsaleable stuff, for which they have had to pay. Therefore, unceasing care has to be taken not to "plunge," and not to anticipate so much as to follow close upon public taste. Net books are perhaps the most satisfactory of all to handle, and yield a profit of 7½ per cent. to the retailer. In this class are included all sorts of technical works, which are published at all sorts of prices. A 15s. educational work will thus yield the retailer 1s. 1½d., a good deal less in proportion than a "half-price" book; but works of this kind are usually obtained to order, do not need to be stocked, and involve no trouble or risk whatever to the dealer.

Dealing with the Wholesalers. A bookseller may either buy directly from the publishers or from the wholesale houses. The great majority of the retailers deal with the large distributing agencies, for only those who can order large quantities of books can afford to trade direct with the publishers, who supply their own list of books only. The large distributing firms in London and the leading provincial centres have vast numbers of booksellers who run accounts and get all their books from them, and these firms employ travellers who call upon their customers to show copies of the more important forthcoming publications. There is no book or magazine too small for these great firms to supply, and the constant complaints which reach publishers from readers unable to secure copies of their books or magazines are proof that many booksellers simply do not know their business, or will not be at pains to secure for their customers the books or papers they most desire. In passing, we may remark that the young man who can get into one of these large wholesale houses for a time in any subordinate capacity will learn much that will be of value to him in the retail trade.

Opening a Shop. We now come to the question of opening a shop. Nothing definite can be stated as to the amount of capital required. One man with experience and knowledge will make a better start with £100 than another lacking these qualifications will do with £500. All depends upon the man and the local conditions. There are so many varieties of bookselling that we cannot describe them all. But we will take three of them.

1. There is, first, the pure bookseller, who, selecting some high-class locality—perhaps in the neighbourhood of one or two schools attended by the children of the better classes—determines to sell books only, and to stock the best class of literature and educational works.

2. Another type is the bookseller who combines books of a good class with cheaper literature; standard libraries, like the "World's Classics"; part publications, like the "Harmsworth Encyclopædia"; and monthly magazines, together with picture postcards, fancy goods, and stationery.

3. The bookseller, newsagent, and tobacconist, who deals almost entirely in "half-price" books of the "bread-and-butter" variety, and in all sorts of periodicals, as well as tobaccos, is a large factor in the trade.

Three Kinds of Businesses. Obviously, the first of these requires the largest capital, as his rent will be greatly in excess of the others', the value of his stock much higher, his accounts longer outstanding, and his whole "style" much more expensive to maintain. In the end his profits are often not greater, and are sometimes less, than those of the other classes; but his position in society is superior—he is less of a tradesman and more of a professional. It is clear, therefore, that unless one has sufficient capital to wait for a year or two before seeing any very substantial results, the first class of business is not one to be lightly entered upon.

The bookseller and fancy goods dealer represents a line of business in which the returns are likely to be quicker and where a smaller capital will enable a man with industry and business acumen to build up a profitable trade in a much shorter time. [See FANCY GOODS AND STATIONERY.] A valuable adjunct to this class of business is to secure an appointment as a branch postmaster, which, while it does not mean a great deal in the way of actual income, for the money paid is usually less by a good way than the services rendered, has indirectly an important effect on the business by bringing a large number of possible customers into the shop. [See POST OFFICE.] In the case of the better-class trade, however, this is a thing to be avoided, because the postmaster must admit all sorts and conditions of people into his shop, and this constitutes a drawback to the high-class trade. The locality must be as carefully chosen for the second class of business as for the first.

A suburban district is most suitable, and the class of literature will be largely conditioned by the local tastes. As a rule, it is not of the highest nor yet is it of the cheapest. A lending library, in which books are lent out at twopence per week, can be run with profit in connection with such a business. Numerous secondhand dealers in London will secure current novels for use in such libraries at considerably less than the trade price soon after they have been published.

The "bookseller, newsagent, and tobacconist" [see under these respective trades] implies a lower middle-class, or working-class locality. It means very long hours, as one must be astir early in the morning to see that the papers are distributed to the errand-lads who take them around to the houses, and the shop must be kept open later than an ordinary bookseller's. The books sold are the very cheapest, limited almost entirely to reprints of standard authors, at 1s. or 1s. 6d., together with juvenile literature, from the 3d. toy-book to the 5s. story by Henty Manville Fenn, and others. The stationery would also be of the cheapest kind.

The whole secret of success in any of the three grades of booksellers we have indicated is to choose carefully one's location, and, having chosen that, to cater as carefully for the tastes of the locality.

The Bookseller at Work. Of course, the clerical side of the business is very much the same as any other, as far as bookkeeping and accounts are concerned, so we shall not enlarge upon it, nor upon the need for accurate monthly statements, where dealing with regular customers; but by far the greater part of the business will be cash, and each one will evolve for himself the system that best suits his requirements. The most important matter is the purchasing of stock. The bookseller must beware of the traveller for the wholesale firm until he has proved him a reliable judge of the literary market, remembering that it is his business to get the bookseller to subscribe for as many copies as possible of the forthcoming book which is going to have a bigger "boom" than any book that has ever appeared before. But really no advice can be given as to purchasing stock; nothing but experience will tell a man what sells in his neighbourhood. He must be guided very largely by the demand at the counter. That is his criterion rather than the opinions of the literary papers, or the enthusiasm of the publisher's traveller.

Studying the Seasons. Of the utmost importance is a shrewd observance of the various seasons; showing and stocking just the kinds of literature for the changing year. Christmas literature is so obvious that it need not be mentioned, but far more might be done by booksellers with maps and guide-books if these were judiciously bought and displayed at the beginning of the spring season. And good results from grouping books of the same character together at such seasons, taking, let us say, 20 or 30, or double that number, of light novels for window display, under the general heading of "Reading for Summer Days," in June, July, or August. If there are schools in the neighbourhood, especially, and often if there are not—for there will be scholars always—some show of educational books, chosen with due regard to the character of the local inhabitants, should be made about the beginning of September.

Publicity. Advertising is as important to the local bookseller as to the great publishing firm. Every publishing house is only too delighted to supply, on application, advertising matter, say, for a new book, a new magazine, a series of books, and the bookseller is wise who distributes these circulars, often prepared at great cost, bearing his own name and address impressed by a rubber stamp, or even printed, if he happens to have a small printing press. Such a press, by the way, is a very good thing for the enterprising bookseller of the second class to possess, as it soon pays for itself and earns a good profit, the wages of a jobbing compositor and a cropper-boy not being at all difficult to meet with the amount of printing noteheads, invoices, visiting cards, etc., which can thus be done "with neatness and dispatch." It costs wonderfully little to keep one's name before the local public if all the facilities are taken advantage of, and the bookseller who does not advertise, by sending circulars round the neighbourhood, continually changing his window and devising new and attractive tickets for the books he is showing, cannot hope to prosper in these days of extreme competition.

Some of the larger booksellers issue elaborate and costly catalogues in which they give specimen illustrations—supplied by the publishers—and admirably arranged lists of new and recent books, most of which they have in stock or can get in an hour or two. This, of course, is the princely way of doing the thing, but it means increase of business. Others, again, have taken to advertising their names in the local papers as having in stock, and willing to send to any address, a given list of the latest books in fiction, science, and so forth. Both of these methods are, of course, beyond the beginner, and presuppose considerable capital and an already established business.

Studying Customers. With booksellers of the first class, especially, there is great need for studying the individual tastes of every regular customer. We know, for instance, of several large booksellers who are so familiar with the tastes of many of their customers that they can tell to a certainty which new books are likely to interest them, and will fearlessly buy these books with the knowledge that these customers will take them. Indeed, in many cases such clever booksellers secure the books and send them out to likely customers on approval, and the amount of good business that may be done in this way is really wonderful. But it requires a man of very shrewd judgment to work on these lines.

While we have deprecated the presumptuous assistant urging his views of literature upon customers who, in all likelihood, are much better informed than himself, we must point out the need to be alert in placing new books before every likely buyer, cultivating the habit of pleasing conversation, and freely showing any work of unusual interest to the customer who seems interested in inspecting the stock.

"Special Lines." Then, of course, in bookselling, as in every other trade, it is well at times to get up some special line which attracts buyers. Annual sales, in which books that have not gone off so well as was anticipated are marked down at a low figure, may, by attracting increase of customers, do something to redeem a loss, and it is always well to make a show of a local author, or a book of local interest, and to push it "for all it is worth"; though not to emulate a Nottingham bookseller, who bought such a stock of a novel by a local writer that in a few weeks he was glad to ticket the book at 6d. per copy less than he had paid for it. A volume by a local minister whose sermons have been published by some good publishing house—but never, oh, never! one who has had his dull discourses printed at his own expense by some tenth-rate firm—is a good line on which to specialise for a while.

Another thing that every enterprising bookseller should do is to arrange with some firm to print a book of good local views which will sell at a reasonable figure, and, by carrying his name as publisher, be an advertisement of his business wherever it goes. A local guide-book, carefully compiled, is also another sure selling production, quite within the scope of any bookseller.

Other Adjuncts. In addition to the several adjuncts to the bookseller's business already mentioned, there are others equally worthy of consideration, which we may briefly mention. Orders will, of course, be taken for bookbinding, but in this matter the bookseller can only act as an agent until he has formed a very considerable business, which would enable him to engage a skilled binder, and do the work himself. Print selling and picture framing form a natural combination with bookselling, and both are fully described in another part of the SELF-EDUCATOR. Then, where space is not so expensive as it is in the heart of the great towns, but where the position is still sufficiently central, a reading and writing room is a good thing to provide as an attraction to customers who are members of the lending library connected with the shop. It very soon pays for itself; and even afternoon teas might be provided at a cost which will make them profitable. A servants' registry is another useful and remunerative agency that may be started. And, in a word, the struggling bookseller must not rest content until he has tried every possible adjunct which can reasonably be associated with his business; for it is all too true that bookselling alone, unless in very special cases, is by no means a very remunerative business nowadays.

Secondhand Bookselling. In some ways the secondhand trade is more attractive than the new. It requires of its followers a thorough love of books for their own sake; a specialised knowledge of the value of old books whose published prices do not always bear any ratio to the prices they may fetch from people who want them, and quick decision in estimating the worth of a bundle of old books put up at auction, a secondhand dealer having to attend numerous sales in search of his stock, though a great deal can also be had by private treaty. Withal, the margin of profit is far better than it is in the new trade, and there is no danger of anything losing value by becoming shop-soiled. It is in the secondhand trade that we look for a man of real literary knowledge, and, although we meet many who are utterly incompetent, the fact that such can make a living indicates that the man who does know books and their value need not fear failure in it.

About Catalogues. Cheap postage has been a great boon to the secondhand dealer, and enables a man of moderate enterprise and moderate capital to push his business wonderfully. He is wise if he specialises in some particular branch of literature while still handling all sorts of books. He might make medical books his special line, or Oriental books, or biography, or sport, travel, poetry, or "first editions." A most important feature of the secondhand trade is cataloguing. If possible, monthly catalogues should be sent out, certainly every second month a revised catalogue should be forthcoming. There is nothing of a special nature to say about a catalogue, as one is like another, and so long as it is properly arranged in alphabetical order, with the names of the books clearly stated, prices and dates given, no more can be done. Some slovenly dealers send out catalogues which are a mere mess of wrongly-spelt and unclassified titles, usually produced in a slum printing house, a thing that makes one afraid of getting disease from touching it. It pays to print a catalogue well. "Who's Who," "The Literary Year Book," and other works of reference, contain any number of addresses to which it is advisable to post each new catalogue, and the volume of business which can thus be done through the post from an address in some suburb, or, indeed, from any part of the country, is surprising. The youth who has the love of books in him need have no difficulty in finding an opening with some secondhand dealer.

The "Back-Number" Business. We need only add, in conclusion, that for one who has some little capital which he can lay out for a few years, and is in no immediate necessity of a return for his money, there is a good opening in the "back number" trade. The idea is to buy old numbers of all the best magazines and part periodicals, have them properly examined to find if they are perfect, and then store away in order of their dates. There is a constant demand for such back numbers to complete sets, and the dealer can afford to sell them at half-price and make a handsome profit, as a sack-load of back numbers will cost him but a shilling or two, and may contain scores of magazines which in a few years will sell out at thirty or forty times what he paid for them, his profit being justified by his waiting and the cost of the space he must devote to a large stock, for a large stock is essential to success.

Continued

SHORTHAND

Eighth Instalment of the Special Course of Shorthand Taught by Sir Isaac Pitman & Sons on their Twentieth Century Plan

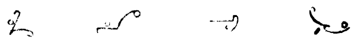
Group 27
SHORTHAND
8

Continued from page 1040

By Sir ISAAC PITMAN AND SONS

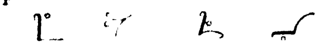
IN addition to the methods of representing vowels and diphthongs shown in the second instalment of this course, there are other devices for vocalization employed in the Pitmanic system to which the student is now introduced. By mastering these instructions he will complete his knowledge of the methods used for the accurate representation of all possible combinations of vowel sounds in the language.

Vocalization of *PL* and *PR*. The *pl* and *pr* series may sometimes be used to obtain a good outline, even though an accented vowel comes between the two consonants. In such a case the LONG dot vowels BETWEEN the two letters are expressed by a small circle BEFORE or ABOVE the consonant stroke; thus



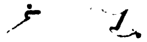
chairman, careless, cashiered, souvenir.

The SHORT dot vowels are indicated by a small circle placed AFTER or UNDER the consonant; thus



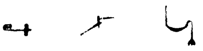
dark, gnarl, German, girl.

In cases where it is inconvenient to observe this rule, the circle may be written on EITHER side, for either a LONG or a SHORT vowel; thus



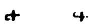
regard, engineer.

A stroke vowel or diphthong is struck THROUGH the consonant; thus



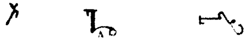
school, record, tincture.

Single stroke words vocalized in the above ways are halved for either *t* or *d;* thus

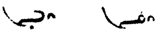


court, cold.

When an initial hook or circle would interfere with a first-place vowel or diphthong, or a final hook or circle with a third-place vowel, the vowel-sign may be written at the BEGINNING or END of the consonant; as

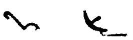


child, dormouse, corporation,



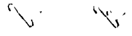
figuration, figures.

It is seldom necessary to vocalize the *pl* and *pr* series to mark an unaccented vowel; thus



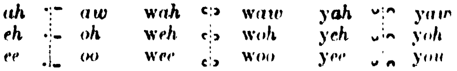
permit, vocal;

but accented vowels may be inserted; thus



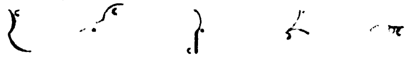
pervert, pervert.

***W* and *Y* Diphthongs.** When *w* or *y* is followed by any simple vowel, a diphthong is formed, which is represented by a semicircle written in the same position as the simple vowel; thus

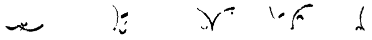


ah	*aw*	*wah*	*waw*	*yah*	*yaw*
eh	*oh*	*weh*	*woh*	*yeh*	*yoh*
ee	*oo*	*wee*	*woo*	*yee*	*you*

The following are examples of the use of the above signs:

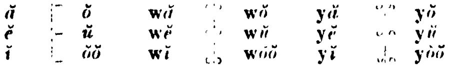


zouave, railway, seaweed, chamois, misquote,



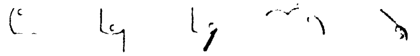
Indiana, associate, yearly, folio, youth.

The same signs written LIGHT represent diphthongs formed of *w* and *y* and the SHORT vowels; thus

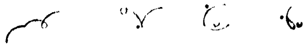


ă	*ŏ*	wă	wŏ	yă	yŏ
ĕ	*ŭ*	wĕ	wŭ	yĕ	yŭ
ĭ	*ŏŏ*	wĭ	wŏŏ	yĭ	yŏŏ

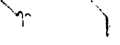
The following are examples of the use of the above signs:



thwack, twenty, twinge, memoir, password,



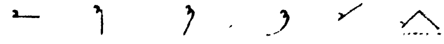
lamb's-wool, serial, alien, atheist,



patriot, piteous.

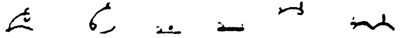
It is in practice rarely necessary to make any distinction between light and heavy signs. It will be seen that the SIDES of the circle ( ) represent the *w* diphthong, while the lower and upper halves ◡ ◠ represent the *y* diphthongs.

The right semicircle ʾ representing *waw* or *wŏ* may be prefixed to a stroke consonant where it is convenient; thus



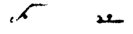
walk, water, watcher, washer, war, warp.

The left semicircle ʿ is prefixed to downward *l*, and the right semicircle ʾ is prefixed to *k, g, m, mp,* to represent *w* only; thus



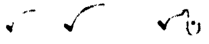
William, Wilson, wake, wig, woman, wampu

This sign is always read *first*, so that when a vowel precedes *w* the stroke must be written, and not the abbreviation, thus



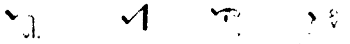
awake, *wake*.

Initial *AW*. At the beginning of a word, the vowel *aw* may be joined to upward *l*, as



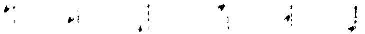
awl, *alter*, *alteration*;

and the logogram *aw* (all) may be joined in compound words beginning with *all-* or *al-*; thus



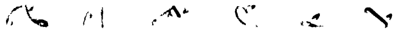
Almighty, *already*, *almost*, *all-wise*.

Disyllabic Diphthongs. In addition to the signs already given for diphthongs, most of which are monosyllabic (or one syllable), the following series of angular characters is employed for the representation of disyllabic (or two syllable) diphthongs.



ah-i, *eh-i*, *ee-i*, *aw-i*, *oh-i*, *oo-i*,

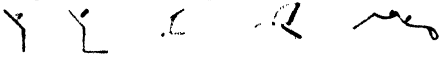
as in



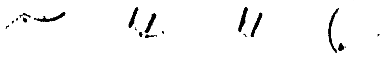
sol-fa'ist, *la'ity*, *howbe'it*, *flaw'y*, *sto'ic*, *bru'in*.

Those signs are written in the same places as the long vowels, and may be used to express a long vowel followed by ANY *unaccented* short vowel which may occur; thus represents the diphthong in *clay'ey* or in *bay'onet*; that in *re'al*, *re'instate*, or *muse'um*; that in *draw'er* or *flaw'y*; that in *Noa'h*, *Noe'l*, or *o'olite*; that in *jew'el* or *Jew'ish*.

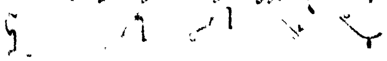
Where a long vowel or diphthong is followed by an *accented* short vowel, separate vowel signs are written, or the *y* series is employed. Compare the following words:



poet, *poëtic*, *re-elect*, *re-éligible*, *reinforced*,

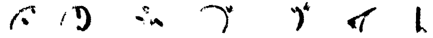


re-énter; *geological*, *geólogy*, *theatre*,



theátrical; *realty*, *reálity*; *pean*; *piáno*.

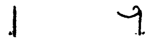
When two vowels occur in succession, not thus provided for, write the separate vowel signs; thus



Leo, *Louisa*, *Ohio*, *Messiah*, *Isaiah*, *royal*, *dewy*.

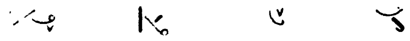
Frequently occurring beginnings and terminations of words are represented in shorthand by single signs, in accordance with the following rules.

Prefixes. The syllable *com-* or *con-* occurring at the beginning of a word is expressed by a light dot written before the first consonant; thus



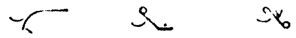
commit, *community*.

When the syllable *cog-*, *com-*, *con-*, or *cum-* comes between two consonants, either in the same or in a preceding word, it is indicated by writing the syllable or word that follows UNDER or CLOSE TO the consonant or word that precedes; thus



recognise, *decompose*, con*fined*, incum*bent*.

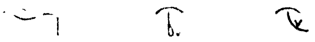
Inter-, *intro-*, or *enter-* is generally expressed by *nt*; thus



inter*lock*, intro*spect*, enter*prise*.

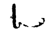
The prefix may be joined when this course does not occasion ambiguity.

Magna, *magne-*, or *magni-* is expressed by a disjoined ; thus



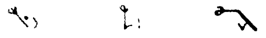
magnan*imity*, magne*tized*, magni*fy*.

Self- is represented by a disjoined circle *s*; thus

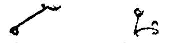


self-*defence*.

In- before the circled letters is expressed by a small hook, written in the same direction as the circle; thus

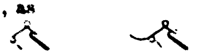


in*spiration*, in*strument*, in*scribe*,



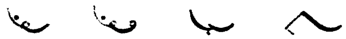
in*herent*, in*human*.

Except in the word *inhuman* (which cannot be mistaken for *human*) and its derivatives, the small hook for *in* is never used in negative words, that is, in words where *in-* would mean *not*. In all such cases *in-* must be written with the stroke , as



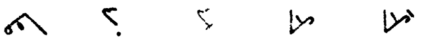
hospitable, *inhospitable*.

Suffixes. The suffix *-ing* is expressed by the stroke , and *-ings* by ; thus



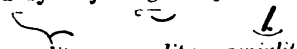
facing, *facings*, *evening*, *robbing*.

When the stroke is not convenient, *-ing* is expressed by a light dot at the end of the word, and *-ings* by a light dash; thus



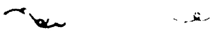
hoping, *plotting*, *plottings*, *turning*, *turnings*.

The suffixes *-ality*, *-ility*, *-arity*, etc., are expressed by disjoining the preceding stroke; thus



formality, *carnality*, *geniality*.

The sign is employed as a contraction for *-ment*, when following *n*, *ns*, or a hook, when it will join easily; thus

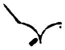


imprisonment, *commencement*.

The cuffix *-mental*, or *-mentally* is expressed by *mnt*; thus

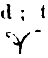
instrumental or *instrumentality*.

Generally *-ly* is expressed by ; thus



poorly.

Where it is inconvenient to join the it may be disjoined; thus

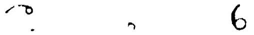


friendly.

The circle *s* is used to express *-self* and the large circle to denote *-selves*; thus

thyself;

it is sometimes joined, as in



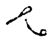
myself, *himself*, *themselves*.

To express *-ship* is used, as in

stewardship.

Sometimes the character may be joined; thus

A disjoined is used to express *-fulness*; thus



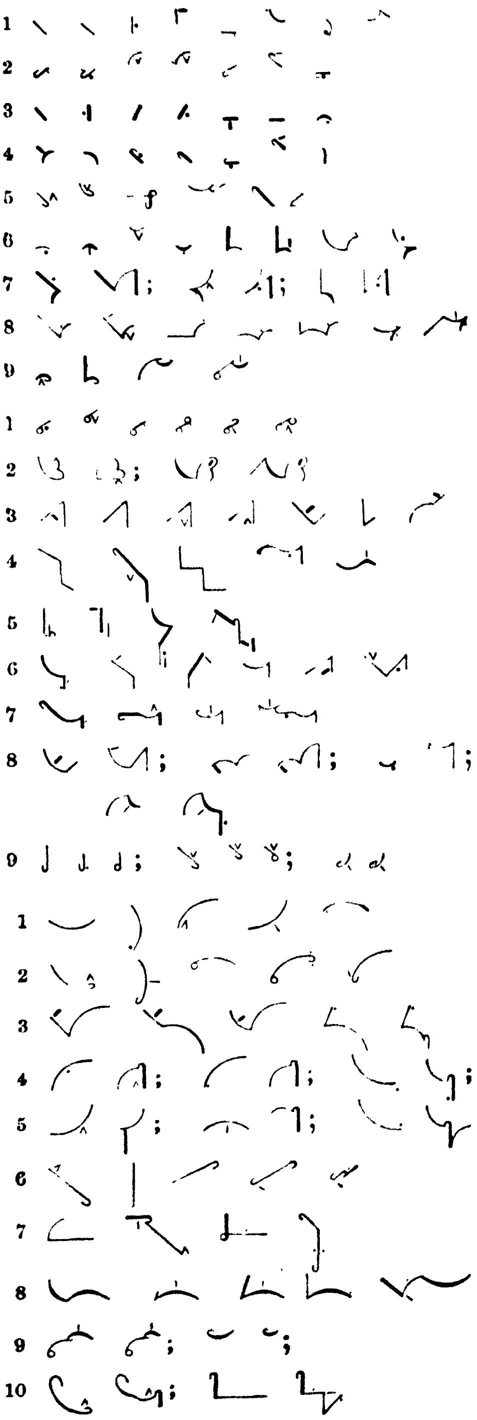
restfulness.

A disjoined is used for *-lessness*; thus

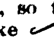
lawlessness.

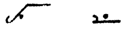
Writing and Reading Practice. At this stage of his study, the student is advised to exercise his shorthand attainments by making use of suitable matter for writing and reading practice. He should obtain "Pitman's Shorthand Reading Lessons, No. 1" (price 6d.), which contains graduated reading printed in shorthand characters; he should also procure "Key to Pitman's Shorthand Reading Lessons, No. 1" (price 2d.), which is in ordinary print. Taking the "Key," he should translate the longhand words and sentences into shorthand, and afterwards revise and correct his work by the printed shorthand of the "Reading Lessons." He will also find it advantageous to utilize the Learner's and Corresponding Style portions of the shorthand pages given weekly in *Pitman's Journal* (price 1d.) in the same way.

KEY TO EXERCISES IN LAST LESSON.



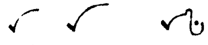
Continued

This sign is always read *first*, so that when a vowel precedes *w* the stroke  must be written, and not the abbreviation, thus

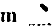


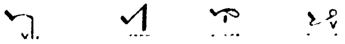
awake, wake.

Initial *AW*. At the beginning of a word, the vowel *aw* may be joined to upward *l*, as



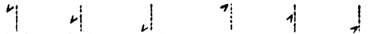
awl, alter, alteration;

and the logogram  *aw* (all) may be joined in compound words beginning with *all-* or *al-*; thus

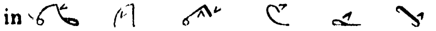


Almighty, already, almost, all-wise.

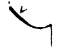
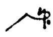
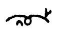
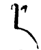
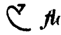
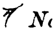
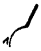
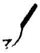
Disyllabic Diphthongs. In addition to the signs already given for diphthongs, most of which are monosyllabic (or one syllable), the following series of angular characters is employed for the representation of disyllabic (or two syllable) diphthongs:



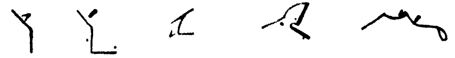
ah-i, eh-i, ee-i, aw-i, oh-i, oo-i,

as in 

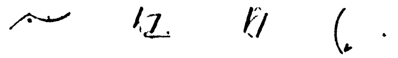
sol-fa'ist, la'ity, howbe'it, flaw'y, sto'ic, bru'in.

These signs are written in the same places as the long vowels, and may be used to express a long vowel followed by ANY *unaccented* short vowel which may occur; thus represents the diphthong in *clay'ey* or in  *bay'onet;* that in *re'al,*  *re'instate,* or  *muse'um;* that in  *draw'er* or  *flaw'y;* that in *Noa'h,*  *Noe'l,* or *o'olite;* that in  *jew'el* or  *Jew'ish.*

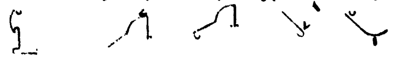
Where a long vowel or diphthong is followed by an *accented* short vowel, separate vowel signs are written, or the *y* series is employed. Compare the following words:



poet, poétic, re-elect, re-éligible, reinforced,

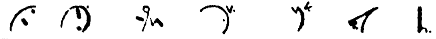


re-énter; geological, geólogy, theatre,



theátrical; realty, reálity; pean; piáno.

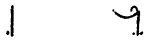
When two vowels occur in succession, not thus provided for, write the separate vowel signs; thus



Leo, Louisa, Ohio, Messiah, Isaiah, royal, dewy.

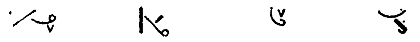
Frequently occurring beginnings and terminations of words are represented in shorthand by single signs, in accordance with the following rules.

Prefixes. The syllable *com-* or *con-* occurring at the beginning of a word is expressed by a light dot written before the first consonant; thus



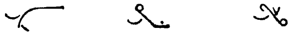
commit, community.

When the syllable *cog-*, *com-*, *con-*, or *cum-* comes between two consonants, either in the same or in a preceding word, it is indicated by writing the syllable or word that follows UNDER OR CLOSE TO the consonant or word that precedes; thus



recognise, decompose, confined, incumbent.

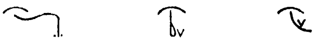
Inter-, *intro-*, or *enter-* is generally expressed by *nt*; thus



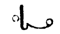
inter*lock*, intro*spect*, enter*prise*.

The prefix may be joined when this course does not occasion ambiguity.

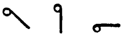
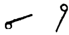
Magna-, *magne-*, or *magni-* is expressed by a disjoined ; thus

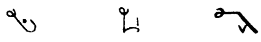


magnan*imity*, magne*tized*, magni*fy*.

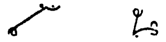
Self- is represented by a disjoined circle *s*; thus 

self-*defence*.

In- before the circled letters  , is expressed by a small hook, written in the same direction as the circle; thus

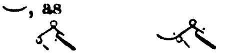


in*spiration*, in*strument*, in*scribe*,



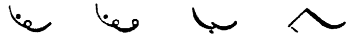
in*herent*, in*human*.

Except in the word *inhuman* (which cannot be mistaken for *human*) and its derivatives, the small hook for *in* is never used in negative words, that is, in words where *in-* would mean *not*. In all such cases *in-* must be written with the stroke , as



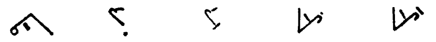
hospitable, inhospitable.

Suffixes. The suffix *-ing* is expressed by the stroke , and *-ings* by ; thus



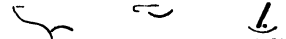
*fac*ing, *fac*ings, *even*ing, *robb*ing.

When the stroke is not convenient, *-ing* is expressed by a light dot at the end of the word, and *-ings* by a light dash; thus



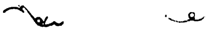
*hop*ing, *plott*ing, *plott*ings, *turn*ing, *turn*ings.

The suffixes *-ality*, *-ility*, *-arity*, etc., are expressed by disjoining the preceding stroke; thus



formality, *carnality*, *geniality*.

The sign is employed as a contraction for *-ment*, when following *n*, *ns*, or a hook, when it will join easily; thus

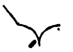


imprisonment, *commencement*.

The suffix *-mental*, or *-mentally* is expressed by *mnt*; thus

instrumental or *instrumentality*.

Generally *-ly* is expressed by ; thus

 *poorly*.

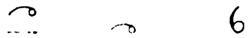
Where it is inconvenient to join the it may be disjoined; thus

friendly.

The circle *s* is used to express *-self* and the large circle to denote *-selves*; thus

thyself;

it is sometimes joined, as in

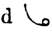


myself, *himself*, *themselves*.

To express *-ship* is used, as in

stewardship.

Sometimes the character may be joined; thus

A disjoined  is used to express *-fulness*; thus

restfulness.

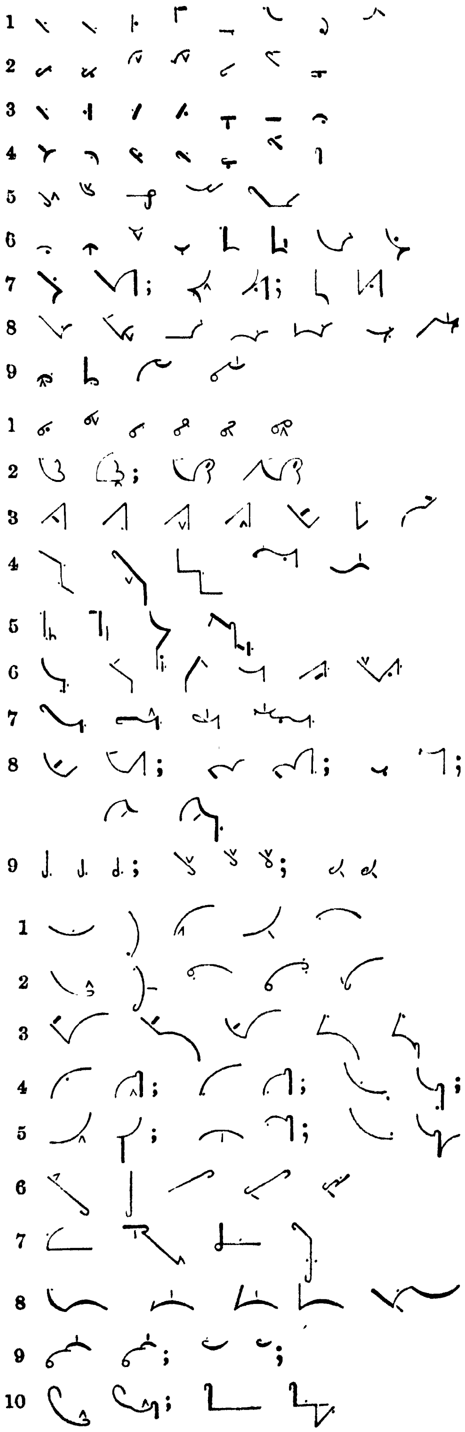
A disjoined is used for *-lessness*; thus

lawlessness.

Writing and Reading Practice. At this stage of his study, the student is advised to exercise his shorthand attainments by making use of suitable matter for writing and reading practice. He should obtain "Pitman's Shorthand Reading Lessons, No. 1" (price 6d.), which contains graduated reading printed in shorthand characters; he should also procure "Key to Pitman's Shorthand Reading Lessons, No. 1" (price 2d.), which is in ordinary print. Taking the "Key," he should translate the longhand words and sentences into shorthand, and afterwards revise and correct his work by the printed shorthand of the "Reading Lessons." He will also find it advantageous to utilize the Learner's and Corresponding Style portions of the shorthand pages given weekly in *Pitman's Journal* (price 1d.) in the same way.

Continued

KEY TO EXERCISES IN LAST LESSON.



Group 10

ELECTRICITY

8

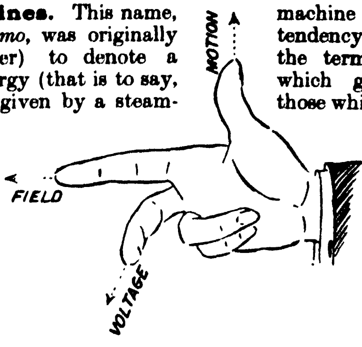
Continued from page 961

THE DYNAMO

Mechanical Generation of Currents. Field-magnets and Armatures. Commutator and Brushes. Armature Windings. Excitation of Magnetism

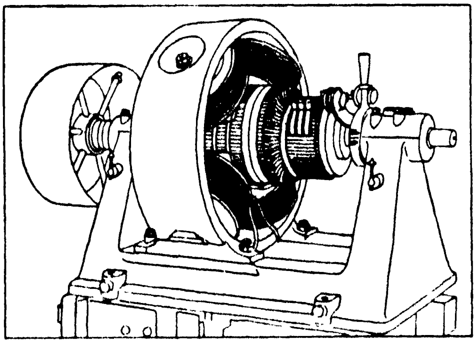
By Professor SILVANUS P. THOMPSON

Dynamo-electric Machines. This name, familiarly shortened into *Dynamo*, was originally coined (Greek *dynamis*, power) to denote a machine in which dynamic energy (that is to say, mechanical energy such as that given by a steam-engine or a turbine) is employed to produce an electric current. In recent years the term has been used, in its general sense, to include all machines the action of which is dependent on the principle discovered by Faraday in 1831, as explained in the preceding article, page 949. That principle was the induction of electric currents by the movement of copper conductors near the poles of magnets in such a way that the conductors cut through the invisible magnetic lines proceeding from the magnet poles. Faraday himself called such machines *magneto-electric*, and this adjective is still retained to denote those machines having a permanent magnet of steel, though Faraday did not so restrict its meaning, but applied it to cases in which steel bars, lodestones, electromagnets, and even the earth itself, were used as magnets. In Germany it has been the fashion to narrow its use to the particular class of machines in which the magnetism is excited by the current generated in the machine itself. On the other hand, the tendency in England now is to confine the term *dynamo* solely to machines which generate continuous currents, those which generate alternating currents being described as *alternators*, but to include those continuous current generators of which the magnetism is independently excited as well as those in which it is self-excited.



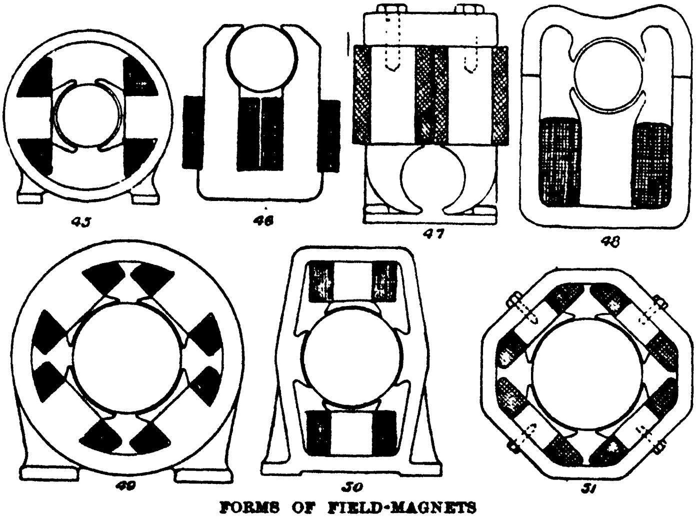
43. RULE OF THE RIGHT HAND

In most dynamos the copper conductors move, while the magnets are stationary; in some the magnets revolve while the copper conductors are stationary, but in the case of continuous current generators this is rare. It is even possible to design dynamos in which both parts revolve, but in opposite directions.



44. A MODERN DYNAMO

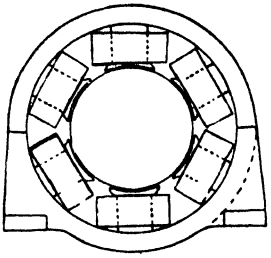
Principle of Reversibility. One most important fact about the dynamo—and it is true of all its many forms—is its reversibility of function. When driven by mechanical power it generates electric currents, but when supplied with electric currents it generates mechanical power. The very same machine that will serve to convert mechanical energy into electrical energy, as a *generator*, will also serve to convert electrical energy into mechanical energy as a *motor*. In fact, it possesses reversibility of function. This is indeed a most precious property, and is made use of in the electrical transmission of power from place to place.

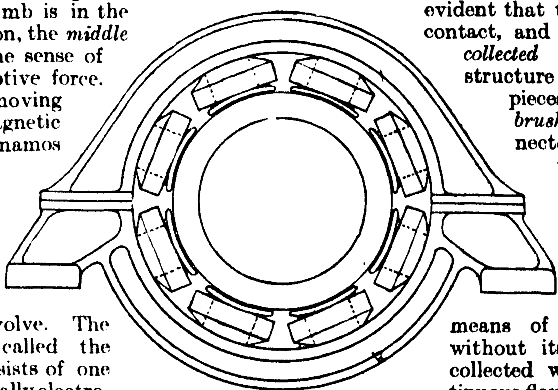


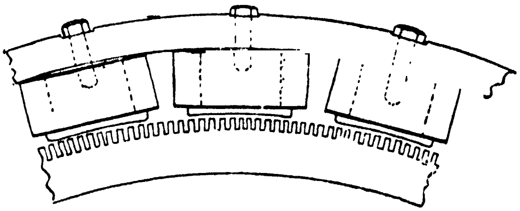
FORMS OF FIELD-MAGNETS

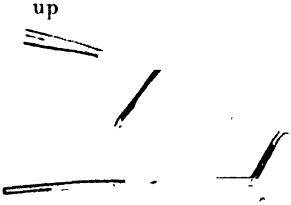
Right-hand Rule for Induction. The induction of an electromotive force in a moving wire, or conductor, tends to send a current along that wire in one direction or the other, and this direction can always be ascertained. In the movement of the conductor laterally across the magnetic lines, we have three things mutually at right-angles to one another—the magnetic lines, the direction of the movement, and the direction of the electromotive force. Now imagine the forefinger, the middle finger, and the thumb of the *right hand* to be set to point in three directions mutually at right angles to one another, as in **43**. Then, if the forefinger is set to point along the direction of the magnetic field, and if the thumb is in the direction of the motion, the *middle finger* will indicate the sense of the induced electromotive force. This is true for all moving conductors in magnetic fields, whether in dynamos or motors.

Field-magnets and Armatures. Every dynamo consists of two principal parts, one of which stands still, while the other is made to revolve. The stationary part is called the *field-magnet*. It consists of one or more magnets, usually electromagnets (page 562) firmly fixed in an iron frame the object of these magnets being to create a magnetic flux, or, in other words, to create a large number of magnetic lines which proceed from its poles. The revolving part is called the *armature*, and it consists essentially of a number of copper wires, or copper conductors, joined up together and grouped in a particular way for the circulation of the currents; these wires, or conductors being wound upon a core built up of laminated iron. In modern machines the cores are made with projecting teeth, and the copper conductors are sunk in slots between the teeth, and held in tightly by binding wires or by wedges. The core is keyed firmly upon the revolving shaft. So, when the armature is set revolving, the copper conductors are whirled round at a high speed. The revolving armature occupies a central position; and is surrounded by the poles of the field-magnet, which send their magnetic lines into the iron core across the intervening gap or clearance. The revolving copper conductors as they fly round cut these invisible magnetic lines, and so, according to Faraday's principle, create or induce electromotive forces. These electromotive forces tend to drive currents along the copper conductors, and so, if the revolving conductors are connected to a circuit, currents will be generated.


52. SIX-POLE FIELD-MAGNET

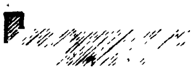

53. EIGHT-POLE FIELD-MAGNET


54. PORTION OF A 24-POLE FIELD-MAGNET

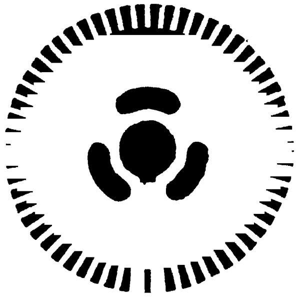

55. AN ARMATURE COIL

Commutator and Brushes. There arises, then, the problem how to connect the conductors of the revolving armature to the wires, or mains, of a circuit. It is evident that this entails a sliding contact, and the current must be *collected* from the revolving structure by means of contact-pieces, technically called *the brushes*, which are connected to the mains, and which press against the revolving structure.

The commutator, however, performs a function much more important than acting merely as a means of gliding contact, for, without its aid, the current collected would not be a continuous flow like the current from a battery. The reason for this is as follows. The poles of the field-magnet are of two sorts, north poles and south poles, arranged alternately. Since the revolving conductors on the armature are moved first past a north pole, then past a south pole, then past another north pole, and so on in continual succession, it follows that the induction of voltage in the conductors will continually reverse, and reverse back. For we may regard each north pole as sending out a flux of magnetic lines across the air gap into the body of the armature, from which these lines emerge to return into the south poles. Hence, if we apply the right-hand rule to the various cases, we shall see that the induction taking place in the conductors will alternate in its direction along the wire. This process, therefore, sets up alternating currents in the armature wires; and, unless these currents were commuted, they would be in a perpetual alternation in the mains of the circuit.

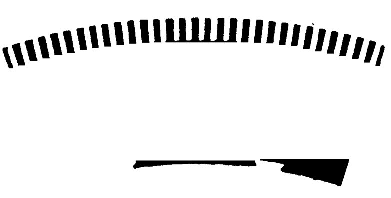

56. A COMMUTATOR SEGMENT

It is the function of the commutator to commute, or change, these alternating currents that exist in the armature, and deliver them to the external circuit as a "continuous" current. By *continuous* is meant *flowing steadily in one direction*, like the current from a battery. Some engineers call such a current a *direct* current, though its process of generation is thus indirect. The term "continuous" is more correct. How the commutator performs its work we shall see presently.

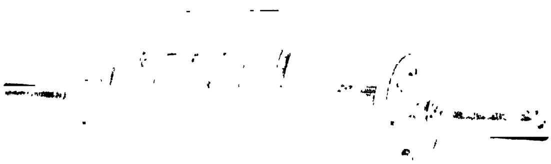


57. ARMATURE CORE-DISC (Sankey and Sons)

A Modern Dynamo. All essential features of a modern dynamo can be observed in the machine depicted in **44**. On the left is a pulley by which it can be driven by a belt from a steam-engine. The shaft is supported by bearings standing upon pedestals which rise from a strong cast-iron bed-plate. Between the pedestals stands bolted to the bed-plate the *field-magnet* system, consisting of a circular frame, or yoke, of cast steel, from which there project inwardly four massive magnet-poles, each surrounded by its magnetising coil. Between these four poles the *armature* revolves—a substantial barrel-like, or cylindrical, structure. At the right-hand end of the armature is the *commutator*—easily identified by noticing that it is a smaller cylinder built up of a number of parallel bars, or segments, of copper. Upon the commutator press the *brushes*. Of these there are two sets, of three brushes per set. The set of three in front can be seen clamped upon a short, horizontal rod, which projects to the left from the curved arm of the *rocker*, or frame, which carries the brush sets. The other brush set is behind the upper part of the commutator.

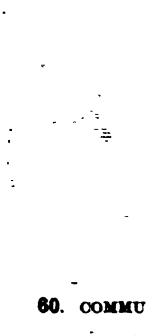


58. SEGMENT OF LARGE CORE-DISC



59. COMPLETE ARMATURE OF A DYNAMO

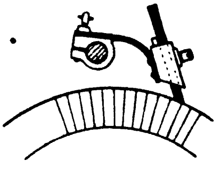
This particular machine is designed to run at 640 revolutions per minute, and to give out a current of 80 amperes at 250 volts. It will, therefore, at full load give an output of 250 × 80 watts—that is, 20,000 watts, or 20 kilowatts. And that it may do this one must put into it mechanically at least 20 kilowatts of mechanical power. Now (p. 290), 1 kilowatt = 1·34-horse power; therefore this machine will require $20 \times 1{\cdot}34 = 26{\cdot}8$ horse power at least. But in all machines there are certain losses due to friction, resistance, etc. If this machine has an efficiency of 94 per cent., then to get the 20 kilowatts (which are the equivalent of 26·8 horse power) out of it, we must put into it $26{\cdot}80 \times 100 \div 94 = 28{\cdot}5$-horse power.



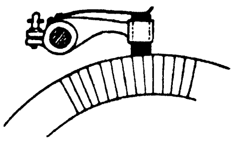
60. COMMUTATOR

Forms of Field-Magnets. Almost all modern dynamos have four or more poles, but many old generators and many small motors of recent date have but two poles. Fig. **45** illustrates a *bipolar* form, suitable for small, enclosed motors, having the pole-cores projecting inwardly from the surrounding yoke. Figs. **46** and **47** illustrate other bipolar forms, the field-magnet being here a species of horseshoe, with its poles upward or downward. This form is still met with in open motors. Fig. **48** is a further development, in which the whole of the exciting coil is wound upon a single core. *Multipolar* forms are preferred for all large machines, and are illustrated in **49** to **54**. Fig. **49** is a four-pole form, practically identical with the magnets of **44**. Fig. **50** is a more special form, in which two of the poles only are wound with exciting coils, the other two being left unwound. Fig. **52** is a six-pole form, often used for machines of 100 to 300 kilowatts. Fig. **53** is an eight-pole tramway generator; it shows how the casting is divided into an upper and a lower half, and how the whole frame is supported. Fig. **54** gives a view of three poles of a large 24-pole generator of 2,000 kilowatts (2,680-horse power). In these large sizes the frame is stiffened by two projecting ribs that run round it. In many cases the ends of the poles next the armature are enlarged by the addition of *pole-shoes*. Fig. **51** is a four-pole form, made very compact, of the pattern much used for tramway motors.

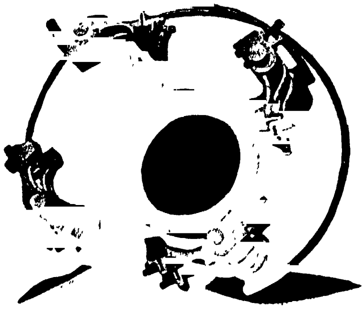
Armature Cores. The core-body which receives the copper winding is nowadays always built up of thin *core-discs*, or stampings of very soft sheet steel, about $\frac{1}{50}$ in. thick. In small machines these core-discs are stamped out in one piece, like **57**, which has a central hole to admit the shaft, and ventilation holes. It is toothed at the periphery in order that when these discs, to the number of some hundreds, have been assembled on the shaft, the core body shall be furnished at its outer part with a series of longitudinal grooves, or *slots*, in which the copper windings can be placed. For armatures that are over 3 ft. in diameter the cores are built up of segments of thin steel, like **56**, attached by bolts or dovetail clampings to a central hub. The object of thus building the core bodies of assembled laminations is to prevent the waste of energy and consequent heating, which would occur by reason of parasitic currents induced in the mass if it were of solid iron. The thin sheets must be lightly insulated from one another by paper or lacquer.


61. A COPPER BRUSH

Armature Windings. The conductors that are to be coiled on the core consist, in small dynamos, of copper wire, cotton-covered, and well lacquered. In very large machines they consist of drawn copper strip insulated by a covering of tape and lacquer. The proper number and arrangement of these conductors will presently be considered. In modern standard machines the coils of the armature are shaped upon wooden moulds, or *formers*, prior to being put into their places in the slots. Fig. **55** shows such a coil, consisting, in fact, of three separate coils taped up together for convenience in handling. They are curiously kinked, or twisted at the end-bends to permit of their being assembled in the slots, overlapping one another, each slot receiving two "sides" of coils, lying one above the other in the slot.


62. A CARBON BRUSH

Re-entrant Windings. The coils, after being put in place, are joined up together in a particular order, the end of one being joined to the beginning of the next, so that they form a continuous series, the end of the last one being finally united to the beginning of the first, and the whole series becoming, therefore, one re-entrant circuit. If a current be brought to any point of a re-entrant circuit, and leave that circuit at any other point, it will obviously have two possible paths of flow from the one point to the other. In every armature there are, therefore, at least *two paths* through the windings; and, as we shall see, there are often *more than two paths*.

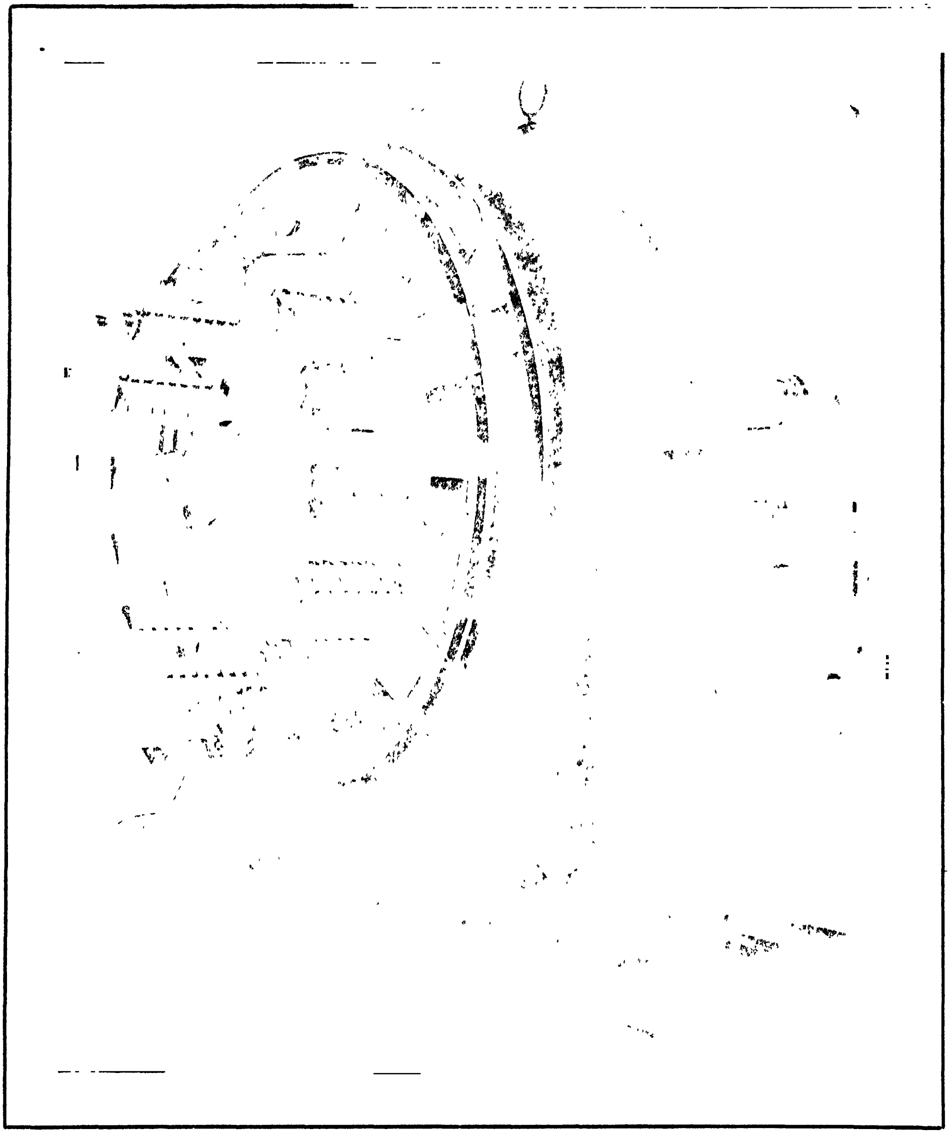

63. BRUSH GEAR AND ROCKER

Winding Pitch. Consider any loop of the winding, such as the loop shown in **55**. If a current is flowing around such a loop, it obviously will flow up one side and down the other. To drive the current around the loop by its own inductive action, as it whirls past the poles, it ought clearly to be of such a breadth from side to side that, while one side is passing under a north pole, the other side ought to be passing under a south pole, and then the two electromotive forces induced will help one another to drive the current around that loop [**63**].

Commutator Construction. The commutator consists of a number of bars, or strips, of copper, of a slightly tapering section assembled together to form a cylindrical structure, as depicted in **60**. The separate bars are insulated from one another with slips of mica, about 0·030 in. thick, interposed between them. The bars are shaped like **56**, with dovetail corners on their under side, so that they can be securely clamped between end-cheeks, and mounted on a shell, or hub, that is secured on the armature shaft. Insulating collars of built-up mica are interposed between the bars and the clamping cheeks of the shell, so that each individual bar is electrically isolated from contact with the neighbouring metallic parts. At the end of each bar of the commutator is attached a metallic strip, called a *riser*, by means of which the bar is connected to the armature windings. Thus, if the commutator has, say, 111 bars, there will be 111 risers connected to the winding, at 111 equidistant points.

Fig. **59** shows an armature complete, with the commutator. The dark markings show ventilating ducts between the windings. The end-bends, as well as the wires in the slots, are held down firmly by numerous bands of steel *binding wires*.

Brushes and Brush Gear. The name *brushes* was given to the stationary contact-pieces which collect the current from the commutator, because in the early machines they were literally made of bundles of springy brass wire. Nowadays, they are either made of bundles of *copper gauze* or copper strips, clamped in suitable *brush-holders* [**61**], or more often of blocks of fine *carbon* [**62**], held in holders, which press with a springy pressure upon the surface of the revolving commutator. In order to adjust the brushes to the proper position to collect the current without sparking, they are fixed to an adjustable frame called the *rocker*, which is itself borne upon the bearing, or else bracketed out from the magnet frame. Fig. **63** depicts a *brush rocker*, showing four sets of carbon brushes together with the pieces of flexible cable to connect them together, two and two, and to carry off the current to the circuit. There are two carbon brushes in each set. Fig. **64** depicts the *brush gear* of a much larger machine, having no fewer than 126 carbon brushes, arranged in 14 "sets" of 9 brushes



64. LARGE 14-POLE DYNAMO FRAME, SHOWING BRUSH GEAR

per set. Carbon brushes will collect from 30 to 40 amperes for each square inch of contact surface. Copper brushes need only about one-third as much contact surface as carbon brushes.

Calculation of Magnet Windings. To excite the magnetism in the dynamo, coils must be wound upon the pole-cores of the field-magnet ; or, rather, coils must be prepared with the proper number of windings of wire of the right thickness and with the right number of turns, being wound up on a lathe, and afterwards slipped into their places on the pole-cores. It is evident, therefore, that some previous calculation is necessary to enable the engineer to ascertain what windings will be right for any particular machine. Such calculations are made in two stages : first, to find the total amount of excitation, in *ampere-turns* [see page 563], that will be needed ; after that, to ascertain the particular size of wire and number of coils that will answer this need.

Conception of Magnet Circuit. It was pointed out on page 565 that, if in any magnetic circuit there are gaps—that is, if the magnetic lines have to emerge from the iron core into the air to cross the air-gap and then re-enter the iron—it will be necessary to provide a much greater circulation of current than would suffice to magnetise to the same degree if there were no gaps. The reason of this is that iron is much more permeable to magnetism than air is. Now, whenever the question arises how many ***ampere-turns*** of excitation are necessary, one must examine two preliminary conditions—namely, what is the nature of the magnetic circuit, and how great a flux is to be produced therein. In a simple horseshoe electromagnet, such as **23** [page 561], the magnetic circuit, or path, consists partly of iron, partly of air. The magnetic flux which emerges from the north-pole surface crosses a gap into the iron keeper, traverses the keeper, emerges again into the air opposite the south pole, crosses the gap again, and re-enters the iron core at the south pole, and follows the iron arch round to the north pole again. In a bipolar dynamo, such as **46** or **47**, the magnetic circuit is much like that of the horseshoe electromagnet, except that the gaps are very narrow. In a multipolar dynamo, such as **44**, **53**, or **54**, there are a number of independent magnetic circuits. For instance, in **54**, if the middle pole is the north pole, the magnetic flux that comes down the middle pole-core and crosses the gap into the armature core will divide, half the lines going to the right and recrossing the gap to go up the right-hand south-pole core, the other half going to the left to re-cross the gap under the pole core. In all such cases we have to calculate separately the excitation needed to send the flux through the different parts, and we must then total up the result for a whole magnetic circuit.

The calculation is complicated by the circumstance that there is always a little magnetic *dispersion*—*i.e.*, some of the flux which emerges from the pole does not cross the gap and enter the armature, but leaks by some lateral path to the neighbouring south poles. By experience we can ascertain how much to allow as a *leakage coefficient*. In ordinary multipolar dynamos 20 per cent. is an ample allowance.

Rules to Calculate the Excitation. For air-gaps, the rule is that the necessary ampere-turns are equal to the flux-density in the gap multiplied by the ***gap coefficient*** **0·3133.** In any iron part we have to calculate by reference to curves of statistics of the magnetism of iron of similar quality, and find from such curves how many ampere-turns per inch length of path are needed to produce in that kind of iron the required flux-density, and then multiply up the figure so found by the number of inches' length of that part.

For example, if we had the four-pole dynamo [**44**] ready built, but still requiring its winding, we should know that the flux from the pole was to be 2,700,000 lines net, or (allowing 20 per cent. for dispersion) 3,240,000 lines in the pole-core. Further, if the area of pole surface is 56 sq. in., the flux-density in the air-gap will be 48,000 lines per square inch. Also, if the pole-core section is 50 sq. in., the density in the iron will be 65,000 lines per sq. in. Moreover, if the teeth are so narrow that the effective section of those under one pole is only 20 sq. in., the density in them will be 135,000. Now, suppose the air-gap to be ½ in. wide, the teeth 1 in. long, the pole-core 8 in. long. Also suppose the curves of statistics to show that to produce a flux-density of 65,000 in the mild steel of the pole-cores required 14 ampere-turns per inch, and to produce a density of 135,000 in the armature stampings required 1,200 ampere-turns per inch, we then have the following calculation for a magnetic circuit.

A.-T needed for 2 air-gaps	= 2 × 48,000 × 0·3133 × 0·5	= 15,038
A.-T ,, 2 teeth	= 2 × 1,200 × 1	= 2,400
A.-T ,, 2 pole-cores	= 2 × 14 × 8	= 224
A.-T needed for one piece of core-body and one piece of yoke, say,		= 800
Total ampere-turns needed per pair of poles		= 18,462

Hence, each pole must carry wire enough to provide 9,231 ampere-turns.

To find the right size of wire we have the rule that it must be such that its resistance per inch length will be equal to the voltage divided by the required number of ampere-turns and by the mean length per turn of the coil. Now, this dynamo is for 250 volts, so that there will be available (allowing 30 volts for regulating rheostat) 220 volts—*i.e.*, 55 volts for each of the four coils. The mean length of one turn will be about 35 in. Hence the wire must have a resistance of 55 ÷ (9,231 × 35) = 0·00017 ohms per inch length. Reference to wire-gauge tables shows that this will be a No. 15 S.W.G. wire, the diameter of which is 0·072 in.

Continued

Continued from page 971

TAILORING FOR WOMEN & CHILDREN

Pressing Tools. Stitches used in Tailoring. Drafting Little Boys' Suits. Taking Measurements. Front and Back Drafting

By Mrs. W. H. SMITH and AZÉLINE LEWIS

PRESSING TOOLS

The Iron (called by tailors "Goose") is the first thing required, and should be at least 10 to 15 lb. in weight.

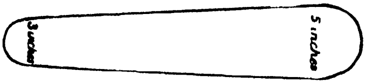
The Sleeve-board can be made at home. A piece of wood, well seasoned and free from knots, ash or beech, 1¼ in. thick and 23 in. long, 5 in. wide at one end, and from 2½ to 3 in. at the other, will be large enough for boys' and ladies' tailoring [1].

There is also the duplex sleeve-board, which is far more useful but a little more difficult to make. This is used for pressing seams, the bottoms of sleeves, trousers, etc. [2].

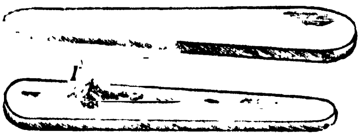
The Sleeve Headboard is, as its name implies, for pressing the top of sleeves. It is useful for pressing such parts as the darts, and any part where the figure is round; also for the bottom of boys' knickers when they are gathered into a band [3].

Damping-cloth. This should consist of ¾ yd. of thin silesia (6½d. a yard), well washed to get every particle of dress out before use. It must be kept perfectly clean; the water and the vessel for it being absolutely clean and free from grease. The cloth must not be very thick or it will retain too much moisture; and as its object is to supply only sufficient dampness to raise steam, it should be wrung as dry as possible before using.

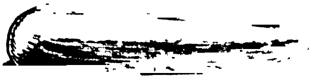
Brown paper, tailor's crayon, a square, pencil, bodkin, tracing-wheel, and wax, are also required for drafting, cutting-out, and making.



1. SLEEVE-BOARD



2. DUPLEX BOARD



3. SLEEVE HEADBOARD

STITCHES USED IN TAILORING

Thread Marking. This stitch must be put into all inlays and inturns—*i.e.*, neck and arm-hole curves, shoulders, pockets, revers, fronts, bottom, sleeve, cuff, etc., to ensure that both sides of the garment are made up exactly alike [4].

Place together the two corresponding portions, and with a double thread work small "running" stitches through both, on the line to be marked, leaving a small loop to each stitch. Cut the loops, draw the two pieces of material slightly apart, and cut the threads between them; *a* shows the first process, *b* the second, *c* the result when the stitches are cut between the cloth.

Serging. This is a very useful stitch for several purposes, such as joining together two pieces of material that are likely to fray, also the pleats of Norfolk jackets and the turnings of bottoms of skirts and sleeves to canvas; in fact, in tailoring, serging is indispensable.

The stitch is formed by passing the needle from back to front of the cloth. It must not go too deep nor be pulled too tightly. This form of stitch should, moreover, neither lie too closely together nor should the stitches overlap each other, as a rough, hard ridge would result, and the object is that the two pieces serged together should lie perfectly flat when pressed [5].

Tailors' Felling. This is an important stitch, as no tailor-made garment can be completed without it; it is used for holding in well-basted linings of every description.

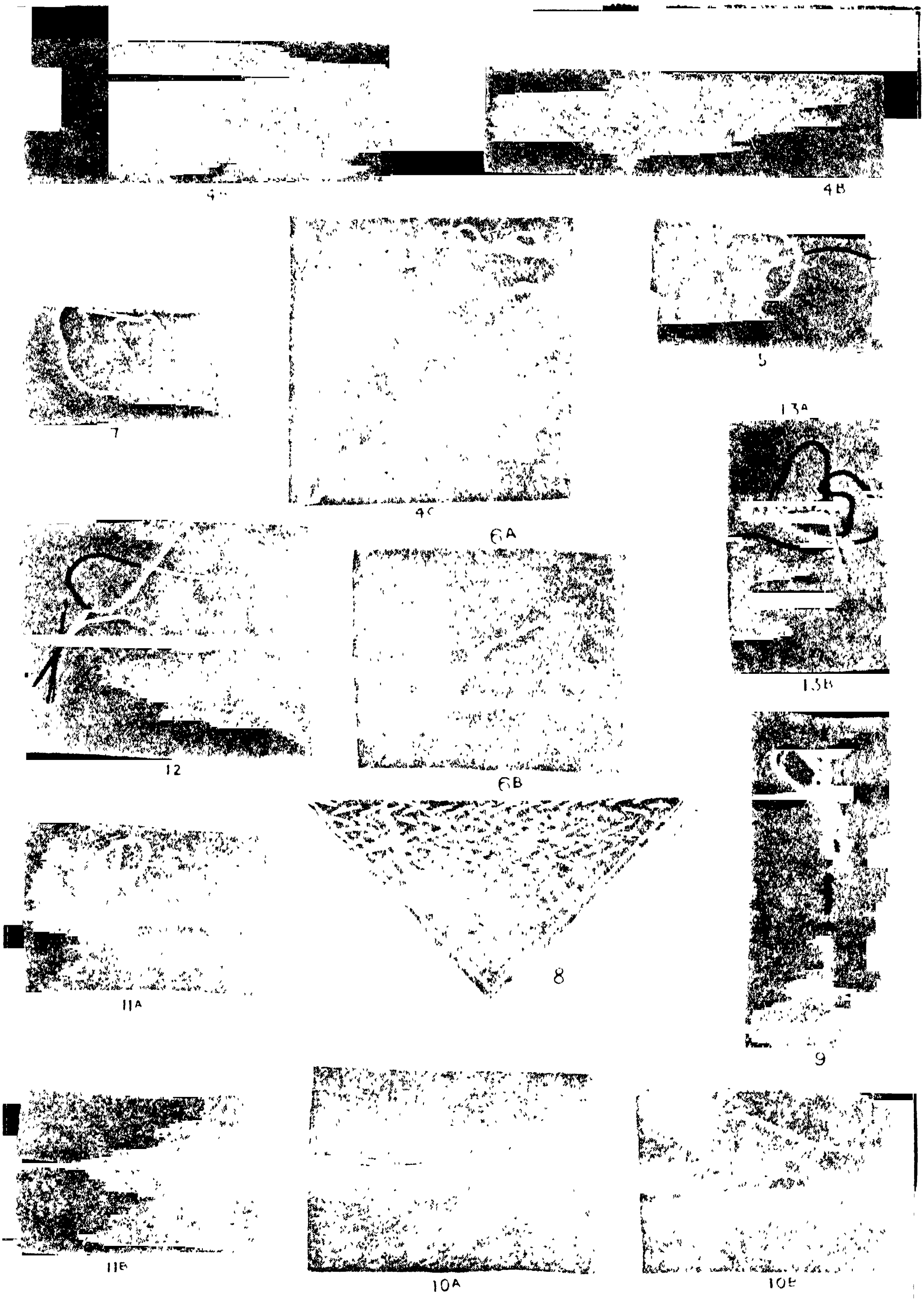
Place the needle in the lining quite close to the edge of the material it is to be felled to, in a slanting direction towards the worker, taking as small a stitch as possible in the material, so that when pulled out it will take hold of the lining. Next insert the needle in the cloth opposite to where it came out of the lining, pull out, and again catch the lining, repeating this till the work is finished. The space between each stitch should be, for fine work, $\frac{1}{16}$ in. apart, for medium ⅛ to ¼ in.

The sewing should not be visible on the upper edge of cloth or material to which the lining is felled.

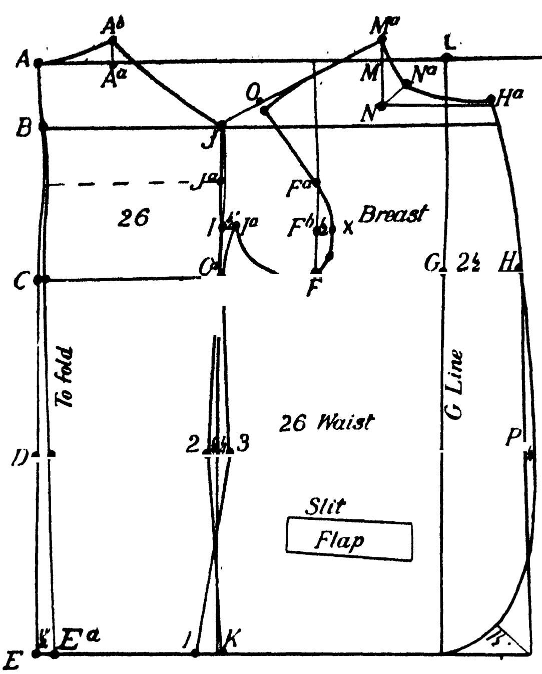
Top Felling. This is done by putting the needle first through the top instead of the under side; it will keep thick fabrics in place better than ordinary felling stitch, and will hold the cloth down much better. By placing the needle in a slanting position the top side can be put on tight or full, as required, according to the slope of the needle, with a proper hold of the cloth [6].

Back-stitching. This is used to sew up seams, linings, pockets, etc. Place the needle as upright in the hand as it can be conveniently held, then push it through the cloth, straight down and straight up. The next stitch must be put in the hole the needle has just left; pull the thread up as lightly as the fabric requires. Thick cloth must be pulled up firmly; thin cloth gently, and so on.

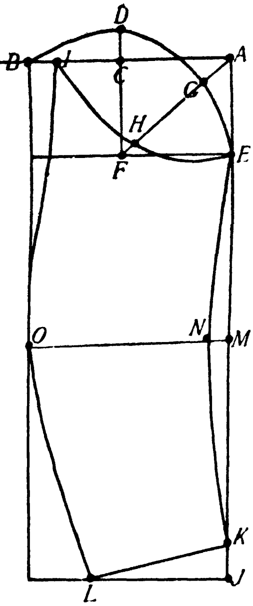
Side-stitching. This is used on the edge of coats, vests, jackets, etc. It is made by placing the needle on one side of the stitch—



4. THREAD MARKING. **5**. SERGING. **6A**. FELLING (Material). **6B**. FELLING (Lining). **7**. SIDE-STITCHING. **8**. PADDING. **9**. BACK AND FORE STITCH. **10**. RANTERING. **11**. STOATING. **12**. DRAWING. **13**. BUTTONHOLE.



15. DRAFTING OF COAT



16. SLEEVE

14. BUTTONHOLE.

that nearest the edge is best—and should be as small as it is possible to make it. Pull the needle up rather firmly, so as to sink the stitch into the cloth ; a little dot made by the stitch is all that should be seen [7].

This is the neatest stitch for the outside work of garments, and, if well done, keeps the edges from rolling.

Padding. This stitch is used to force canvas on to the turns or revers of coats and collars of all kinds of garments that require canvas to hold them in place.

The cloth must be held in a rolled manner over the fingers, and the stitch taken as lightly as possible on the cloth, only showing a small dot on the under side. It is worked up from right to left, and down from left to right, about ¼ in. apart, forcing the canvas on a little each time a stitch is taken—*i.e.*, working the cloth from underneath with the forefinger, and pushing the canvas very slightly with the thumb, to make the work form a roll [8]. Each row must be the same distance apart, and each stitch midway between those on previous row. To produce good results Raven silk should be used ; it is to be bought in skeins, and can be had at any tailors' trimming warehouse.

Back and Fore Stitch. This is useful where strength is not required. Make two back stitches and one forward, then one back and one forward all through. This is useful for sleeve linings and other light work, such as linings of skirts and jackets [9].

Rantering. This is used to close up a seam that looks unsightly, the object being to make it invisible.

First sew the seam with back stitches about ⅛ in. apart, taking the needle back half way into the previous stitch all through. To produce thin results the work must be done with fine needle and silk [10*a*].

After sewing the seam, double the edges back on the right side, working them as close to the edges as possible with the finger and thumb. Take a fine needle and silk, pass it in a perfectly straight line (from and towards the worker) through the extreme top of the edges, between every thread of the material; this is important, as the seam must lie perfectly flat [10*b*]. When finished, scratch the edge of the material lightly to raise the nap ; then, also very lightly, press the wrong side on a bare board. On no account draw the iron along.

Stoating. First place the edge of the material together, wrong side up, and mark at regular intervals of at least 1 in. with a tailor's crayon. The edges are then held together by the left forefinger and thumb, and the needle is passed in a perfectly straight position from the top through half the thickness of the material—*i.e.*, splitting the cloth. The stitches must on no account show on the right side. It should also be remembered that in drawing it up, the stitch should be pulled rather tightly. Stoating is best applied on stout, firm cloth, the edges of which will admit of splitting, such as Meltons, beavers, boxcloth, etc. Fig. 11*a* will give some idea of the way this form of stitch is applied.

The chalk marks must be kept opposite each other all through. When the seam is finished it should be rubbed with warmed wax, placed on a bare board, wrong side up, slightly damped, and pressed with a rather hot iron, which must be lifted up, *not* moved along. Fig. 11*b* shows the process completed and right side of cloth.

Drawing-stitch. This is applied on the right side of material without any seams being taken. It is employed for joining the ends of collars to revers, etc. Use a very fine needle and silk. After securing the first stitch [12], place the needle in the top of rever, bring it round, taking the smallest possible hold of the collar; bring the needle up tightly, insert it again directly opposite where the last stitch came out, and proceed as before. Mark the edges as in stoating to keep them even, and press when finished.

Buttonholes. First mark the position of the holes at equal distances apart. The eye of the hole should be ⅜ in. from the edge of the garment and ¼ in. longer than the diameter of button. No matter what the material may be, it is advisable to stitch round the mark before cutting, to prevent the top and under edges from slipping; this enables one to work the hole with more ease [**13**].

Holes are usually barred with double twist, thread, or gimp. Twist is preferable, as it wears so much better, and should always be used in the best work; the two latter methods cut the twist, and give to the holes a stiff appearance which they should not have.

To "bar" the hole, a No. 5 needle and No. 10 twist will be required. Take a length of twist from ¾ to 1 yd., according to size of buttonhole, and make as small a knot as possible. Insert the needle between the cloth and facing to hide the knot, bringing it up as near the edge as possible [**14**]; send it down at 2, up again at 2, down at 3, up again at 3, and down at 4. The twist should be drawn rather tightly, and lie along the hole at an equal distance from the edge. Repeat the operation, which will produce a double twist bar. Fig. 13*a* shows the hole cut and barred, and the needle placed in position, before making the first stitch. Bring the needle up at 1, about 1/16 in. from the edge, cast the two threads which hang from the eye of the needle round the point, from right to left [*a*], draw the needle out in an upward and forward direction, taking care to have the loop, or purl, exactly on the edge of hole, and continue the stitch to 2 (2 and 3 represent the eye of the hole). The stitches should now be closer together, the purl pulled well up at this point, and the eye kept as round as possible; complete the hole in the same way as from 1 to 2.

Now bar the end. To do this, hold the garment with the eye of the hole towards you, make 3 or 4 bars from 4 to 1, bring the needle up at 4 and make 3 or 4 loop stitches, put the needle down at 1, fasten off neatly and securely.

The holes are now ready for the finishing process. Press the two edges together with the thumb and finger, oversew lightly with two or three stitches near the eye, place a cloth over the hole and press, insert a bodkin or stiletto in the eye, and give two or three sharp turns. The buttonhole is now completed [**13*b***].

DRAFTING BOYS' SUITS

In drafting and making boys' garments—that is, little boys from about 6 to 8 years old—it is of the greatest importance that they should be easy in fit, yet not so big as to be unsightly. Extremes in either case must, of course, be avoided; a tight fit for boys is certainly a mistake, and is not conducive to health. In the case of tall, thin boys, it exaggerates the slimness, and for those of opposite build, it accentuates the stoutness; in neither case does it add to the beauty of proportion. Coats for slim boys should hang as straight as possible from the back of arm to bottom of coat, to broaden the figure.

Having thus dealt with the necessary preliminaries, we can proceed with the drafting of a boy's suit for the following measures—*viz.*, 26 in. breast, 26 in. waist, 12 in. neck, 12½ in. back, 19 in. full length, sleeve from centre-back to wrist 22½ in.

Measurements. Round the lower part of neck, 12 in.

Back. Place the end of inch tape on the nape of neck (to do this correctly, you must feel for the small round bone that connects the vertebræ or backbone, with the bones of the neck), measure to hollow of waist, 12½ in., on to full length, 19 in.

Round the chest—not tightly—26 in.

Sleeve, from centre-back, on to wrist, 22½ in. Working scale: half breast, 13 in.; ¼ in. turnings are allowed on all seams.

The Drafting. A piece of paper 20 in. long and 18 in. wide is required. Square lines 1½ in. down from the top and 1 in. in from edge. Letter the left-hand corner A.

Back Drafting. A to B, one-sixth of back length (2¼ in.), A to D, length of back (12½ in.); B to C, one-third (4⅜ in.); A to E, full length (19 in.); E to E^a, ½ in. Draw line from E^a to A; square lines at right angles from B, C, D, and E. A to A^a, one-sixth of neck; A^a to A^b, ½ in.; from back line to C^a, one-third of breast, plus 1¼ in. (5½ in.); to F, two-thirds; to G, half breast; to H, 2½ in. more than the measure.

Square line from C^a to B line; C^a to I, one-twelfth; I to I^a, ½ in. Make J top of line on line B; back line to J^a, half the distance from A to C (see broken line). Draw line from J through C^a to bottom of coat and make K. K to 1, one-twelfth (about 1 in.); 2 and 3 are ¼ in. to right and left of K line. Draw lines from K through 2 to C^a.

Curve from I to J; slightly curve back-shoulder line from J to A^b; and neck from A^b to A [**15**].

Front Drafting. F to F^a, one-sixth, plus ½ in.; F^b is midway between. F^b to X, ½ in. Square line up from G to neck line, make L, continue line G to bottom of coat. L to M, one-sixth of neck; M to M^a, ¾ in.; M^a to N, one-sixth of neck.

Square line from M^a and N to 1½ in. out from G line; make H^a. N to N^a, half the distance from M^a to N; G line to P, ½ in. more than G to H. Draw line from H through P, to bottom of coat; mark off the corner 1½ in. (or more if desired).

Curve from G line through this point to ¼ in. out from P, on to H; slightly curve from H to H^a.

Neck Line. Curve from H^a through N^a to M^a; draw front shoulder from M^a to J. Make O same length as back shoulder; drop O ¼ in. before curving, to take off the sharp angle at that point. Curve from O, through F^a, X, and F to I^a and from E through 3 to I for side of front [**15**].

Continued

Group 23

NATURAL HISTORY

8

Continued from page 916

HOW PLANTS PROTECT THEMSELVES

Defences of Seed-plants against Weather and Animals. Life History of the Fern. Alternation of Generations. Fern-like Plants

By Professor J. R. AINSWORTH DAVIS

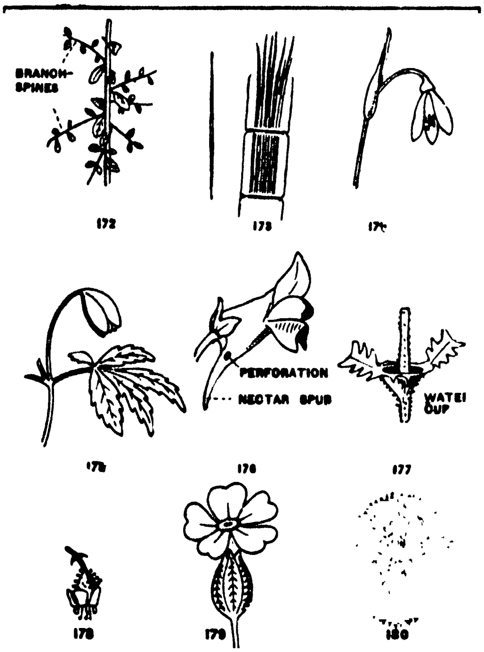
Defences of Plants. Enough has already been said about the way in which drought-plants (*xerophytes*) tide over the unfavourable season of the year, and this must serve as a partial illustration.

The numerous cases where plants possess spines, thorns, prickles, etc., are partly at least to be interpreted as adaptations whereby defence against many vegetarian enemies is more or less attained. In the sloe (*Prunus communis*), for example, the spines are modified branches [**172**]; in gorse (*Ulex Europaeus*) they are branches and leaves; and in cacti, leaves (*Echinocactus*), a photograph of which [**135**] appears on page 909; while in holly (*Ilex aquifolium*) the prickly leaves answer the same purpose.

The grubs of many beetles live in wood, upon which they feed. This probably gives a clue to the primary use of the important commercial substances india-rubber and gutta-percha, which are the dried sticky juices of various shrubs and trees living in hot climates. Beetles of the wood-boring kind, which seek to pierce and lay eggs in such plants, are liable to be snared and killed by the viscid fluids which ooze out.

Arums, and various other plants, ward off the attacks of snails and slugs in a rather curious way. The outer parts of their stems and leaf-stalks contain bundles of excessively sharp crystals (*raphides*), composed of oxalate of lime [**173**]. These pierce the soft mouths of snails and slugs like so many needles, conveying a lesson which is usually taken to heart.

Readers who have followed this course will realise the importance of the fertilising dust known as pollen. Since it is very liable to be spoilt by moisture, a number of devices have come into existence by which this is prevented.



172. SLOE. 173. RAPHIDES (slender needle-like crystals). 174. SNOWDROP. 175. WOOD ANEMONE. 176. TOADFLAX. 177. TEASLE. 178. GOOSEBERRY. 179. SILENE INFLATA. 180. SWEET CHESTNUT (rounded husk covered with slender spines).

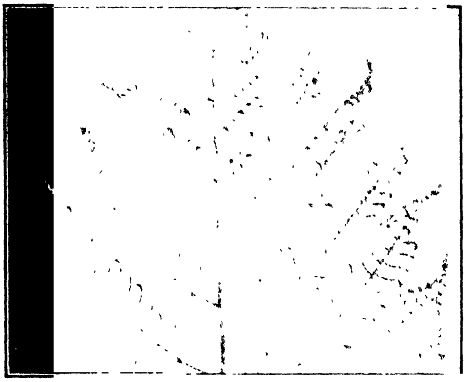
Bell- or cup- shaped flowers hanging upon curved stalks protect their pollen very effectually, as may be seen in Canterbury bell (*Campanula*), heath (*Erica*), snowdrop (*Galanthus*) [**174**], and lily of the valley (*Convallaria*). There are also many flowers which bend over in rainy weather so as to shield the pollen, among which are herb Robert (*Geranium Robertianum*), daisy (*Bellis perennis*), willow herbs (*Epilobium*), and wood anemone (*Anemone nemorosa*) [**175**]. In other cases—*e. g.*, lime (*Tilia*), an illustration of which [**146**] appears on page 911, and balsam (*Impatiens noli-me-tangere*) — the foliage-leaves serve as an umbrella.

In many members of the dead-nettle and foxglove orders (*Labiatæ* and *Scrophulariaceæ*) the opening of the corolla is at the side: or in some of the latter, such as toadflax (*Linaria*) [**176**] and snapdragon (*Antirrhinum*) it is completely closed except during insect visits.

The closing of many flowers on the approach of rain is a common device by which pollen is protected, and is exemplified by roses, gentians, and crocuses.

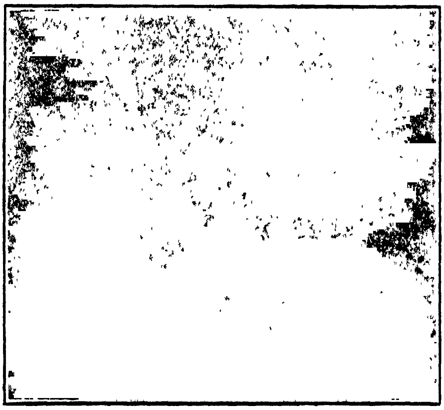
Protection against Unbidden Guests. While flowers lay themselves out, so to speak, to attract insects of a certain kind which are able to transfer pollen, the flowers themselves, or the pollen and nectar they provide as rewards for their industrious servants, prove tempting to other insects, and sometimes to snails and slugs, which are unable to perform the work required of them. Such "unbidden guests" are debarred from access to the flowers by a great variety of ingenious devices.

The flower must also be protected against unbidden guests which creep up from the ground. These are mostly creeping insects, which find their upward progress barred by water barriers, slippery or sticky surfaces, or obstructions of bristles or sharp hairs. In certain teasles (*Dipsacus*) [177], for instance, the foliage-leaves are in opposite pairs, and their bases unite together to form a cup in which water accumulates. Some of the catch-flies (*Silene*) and campions (*Lychnis*) have sticky stems, which not only prevent the visits of undesirable forms, but entangle and hold them so firmly that they perish miserably, and in gooseberry (*Ribes grossularia*) [178] there are viscid hairs on the calyx which answer the same purpose. In certain willows (*Salix*) approach to the flowers is prevented by wax-covered slopes as slippery as glass, which give no foothold, while a curved flower-stalk, such as that of snowdrop (*Galanthus nivalis*) [174] may debar entry. Obstructions are well seen in the prickly bracts which closely invest the flower-heads of thistles.



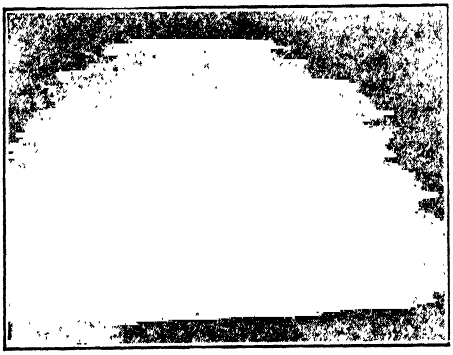
181. FERN

182. HORSETAIL



183. HAIR MOSS (Polytrichum)

There are some plants, such as certain balsams (*Impatiens*) which secrete nectar at the bases of their foliage-leaves to attract unbidden guests which are climbing up to the flowers. Ants, in particular, are very fond of sweet substances, and commonly content themselves with this lure, which saves them the trouble of going further. Snails and slugs are effectually kept away by spines, thorns, and prickles, as in gorse (*Ulex Europæus*), sea-holly (*Eryngium maritimum*), and many others. These unbidden guests do not seek pollen or nectar, but devour the flowers bodily



183A. MOSS

(Photographed by Prof. B. H. Bentley)

Many of the more specialised flowers can only be usefully served by a limited circle of visitors, and others have to be excluded. Tangles of hairs or gratings of bristles are often found within the flower itself, and effectually protect the nectar against smaller and weaker insects. Such may be found in the buckbean (*Menyanthes*), some honeysuckles (*Lonicera*), and some speedwells (*Veronica*), while in many instances the mechanism of the flower may be compared to a lock of which only the legitimate visitors possess the key. This is well exemplified by most members of the pea and dead-nettle orders (*Leguminosæ* and *Labiatæ*).

There are several thieving bees with tongues too short to reach the nectar-stores of certain flowers, and these intelligent creatures have found it possible to bite through the outer investments and steal the desired treasure without earning it [176]. One device for preventing this is found in the bladder campion (*Silene inflata*), where the large inflated calyx stands at some distance from the treasure-house [179]. Should a nectar-thief gnaw a hole through this it is no better off than before, for its tongue is too short to stretch through to the nectar.

Many flowers of pale hue which court the attentions of moths only exhale a fragrant odour in the evening, when their guests are on the wing, and may even remain closed during the day. In this way they to some extent escape the notice of undesirables. Honeysuckle (*Lonicera*) may serve as an example.

There are also some plants which maintain a body-guard of ants to repel the attacks of voracious beetles, but do no harm to the flowers. These plants belong to the dandelion order

(*Compositæ*), and they reward the services of their retainers by nectar, which is secreted by the scales surrounding the heads of flowers.

We have seen that many fruits are destined to be eaten by birds or other animals, the strongly coated seeds escaping digestion. But it is necessary that such fruits should be protected while they are ripening. For this purpose many of them are enclosed in prickly husks, as sweet chestnut (*Castanea*) and beech (*Fagus*) [**180**]. Still more commonly the unripe fruit is acid, bitter, or even poisonous, and is thus effectually shielded from most attacks. Seeds, when mature, are frequently so flavoured that they do not commend themselves as an article of diet.

Certain other methods by which fruits and seeds are protected have been already spoken of in the section on "Dispersal" (page 909).

The highest group (*Pteridophytes*) of the seedless plants contains many familiar forms, among which ferns and their allies (*Filicinæ*) take a leading place. It also includes horsetails (*Equisetinæ*), and club-mosses (*Lycopodinæ*).

Former Importance of Fern-like Plants. That part of the geological history of the globe during which we know positively that organisms existed is divided into three great epochs—Primary, Secondary, and Tertiary. The last and shortest of these, which includes the present period, is characterised by the dominance of pod-plants (*Angiosperms*) on land, while naked-seeded plants (*Gymnosperms*) were supreme during the much longer Secondary epoch. Before this, in the immense period of time embraced by the Primary epoch, fern-like plants played by far the most important part in the vegetation of the land. During a part of this epoch the coal-measures of Britain slowly accumulated, and they are chiefly made up of the remains of such plants, some belonging to groups which are now entirely extinct, while others are represented at the present time by species which are mostly small or even of insignificant size.

FERNS (Filicinæ)

Tree Ferns [**184**]. The hot, damp forests of tropical and sub-tropical regions may be regarded as the headquarters of the fern group. In parts of the southern hemisphere—notably Ceylon, Australia, and New Zealand—some ferns grow to the size of trees, and may even make up forests. They somewhat resemble palms in appearance, consisting as they do of a long, bare trunk, bearing a crown of feathery leaves.

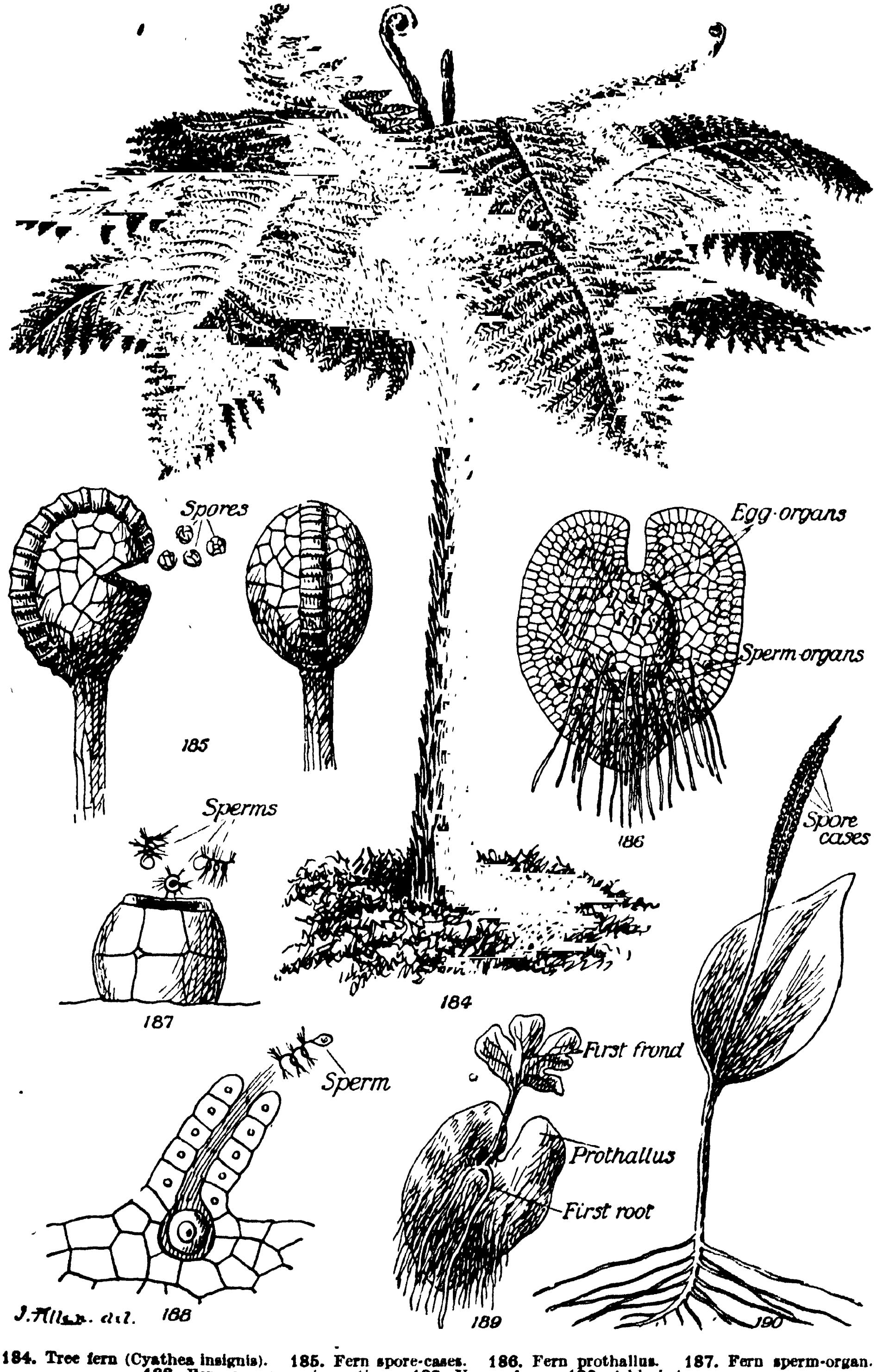
Parts of a Fern Plant. A fern plant of the kind familiar in this country generally consists of an underground stem (rhizome), which may creep horizontally at some distance below the surface, as in bracken (*Pteris aquilina*), or may be obliquely embedded in it, as in male fern (*Aspidium Filix-mas*). The stems of other species are attached to the bark of trees, or find a home in the crevices of walls or rocks. Brown branching roots grow out from the stem, and serve, as usual, the double purpose of fixation and absorption of a part of the food. The leaves or fronds grow in the contrary direction into the air and light, and do the same work as in seed-plants. They are sometimes broad and unbranched, as in the hart's-tongue (*Scolopendrium*), but their shape is commonly more or less feather-like [**181**]. Young fern fronds are rolled up in the shape of a bishop's crosier, and are thus enabled to force their way up through the soil without getting damaged.

The Life History of a Fern. Probably everyone has noticed regularly arranged brown patches on the backs of fern fronds [**181**]. Each of these is termed a *sorus*, and species differ considerably according to the shape of sori and their manner of distribution. In bracken they are close to the edges of the frond, and follow its outline ; in hart's-tongue they are long streaks diverging from the middle of the leaf, while in polypody (*Polypodium*), so common on tree-trunks, and male fern they are round patches [see also **181**]. A sorus may have no special investment, as in polypody, or it may be covered by a membrane (*indusium*), as in male fern. In some cases there are special fertile fronds of different shape from the others, upon which the sori are borne, instances being afforded by the hard fern (*Blechnum boreale*) and royal fern (*Osmunda regalis*), the latter being our largest native species.

Spore-cases and Spores. Examination of a sorus under the microscope shows that it is made up of a number of stalked spore-cases [**185**], in which are contained a number of angular brown spores. A spore-case is of biconvex shape, with a thickened ring (*annulus*) running round the greater part of its margin. This band is in a state of tension, and when the spores are ripe it tears open the case and scatters them in all directions.

Germination of the Spores. The spores are cells of simple structure, and must not be confounded with seeds, for, as we have already learnt, these are of very complex character. A spore, too, is not, like a seed, the result of a process of fertilisation, but is asexually produced. Should it reach a damp spot it at once germinates. Its firm coats split, and two outgrowths make their appearance—a delicate, colourless, root-hair which grows down, and a green thread that makes its way upward. But few spores are able to effect their work of continuing the species. It has been calculated that, on an average, only one spore per plant succeeds in doing this each season. And if these little bodies were not produced in vast numbers, ferns would soon become altogether extinct. We should naturally expect that the germinating spore would grow at once into a new fern plant ; but this is not the case. It gives rise to a small heart-shaped, green expansion, the *prothallus* [**186**], attached to the soil by numerous root-hairs. Prothalli may often be seen in quantity in greenhouses, growing on the mould in which ferns have been planted. The artificial conditions are very favourable to their production.

Egg-organs and Sperm-organs. Upon the under side of the prothallus, in its central region (the cushion), which is thicker than



184. Tree fern (Cyathea insignis). **185.** Fern spore-cases. **186.** Fern prothallus. **187.** Fern sperm-organ. **188.** Fern egg-organ in section. **189.** Young fern. **190.** Adder's-tongue.

its edges, will be found a group of egg-organs [188], each of which consists of a basal part, embedded in the prothallus, and containing an egg-cell, and a projecting curved region. Scattered about on the same side of the prothallus, but restricted to its thinner part, are a number of very minute hemispherical projections, the sperm-organs [187], in each of which are produced a quantity of excessively small sperms, shaped like fragments of corkscrew, and beset with delicate threads of protoplasm, in constant movement, enabling the sperms to swim about in the film of moisture covering the prothallus.

Fertilisation. Within the mature egg-organ a sort of slime is produced, which swells up and forces apart the cells making up the projecting portion, so as to leave a passage down to the egg-cell. Meanwhile, the ripe sperm-organs have been burst open in similar fashion, and the liberated sperms swim actively about. The slime which oozes from the egg-organs exerts a chemical attraction upon them, and should a sperm succeed in making its way down to an egg-cell it fuses with it. This act of fertilisation is precisely comparable to the process described under the same name for seed plants And it is particularly interesting to notice that among the lowest of the latter (*Cycads*), the pollen-grain gives rise to motile sperms, instead of growing out into the usual pollen-tube.

Development of the Fertilised Egg-cell. The fertilised egg-cell at once begins to divide, and soon gives rise to a young fern-plant [189], which remains for a time attached to the prothallus, but ultimately drops off and takes root in the ground. The prothallus now perishes.

Alternation of Generations. We see, therefore, that the life-history of the fern includes two alternating stages: (1) The ordinary fern plant, which produces spores asexually, and (2) the prothallus, possessing egg-organs and sperm-organs. We may call these the *Spore-generation* and the *Egg-generation*, and show their relationship thus:

$$\underset{\text{(fern plant)}}{\text{SPORE-GENERATION}}\text{—spore—}\underset{\text{(prothallus)}}{\text{EGG-GENERATION}}\left\{\begin{matrix}\text{Egg-organ—egg-cell}\\ \text{Sperm-organ—sperm}\end{matrix}\right\}\begin{matrix}\text{Fertilised}\\ \text{egg-cell}\end{matrix}$$

This remarkable phenomenon is known as "alternation of generations," and is typically seen in fern-like plants, mosses, etc., and many lower forms of plants. It is also characteristic of seed plants in a somewhat modified form.

FERN-LIKE PLANTS

Adder's - tongue and Moonwort. These small and rather uncommon British ferns differ in several ways from their allies just described, for they possess but a single leaf, which divides into a sterile and a fertile part, while each spore-case develops from a group of cells, and not from a single one, as is the case in an ordinary fern. In the adder's-tongue (*Ophioglossum*) [190], the sterile part of the leaf has a simple outline, while the elongated fertile portion is practically a mass of closely crowded spore-cases. But in moonwort [191] both parts of the leaf are branched in a feather-like manner.

Water-ferns (*Hydropteridæ*). These make up a small but interesting group of little plants which are either purely aquatic, or grow with some exceptions in swampy ground.

The lake quillwort (*Isoëtes lacustris*) [192] is found in this country growing at the bottom of mountain lakes, from North Wales northwards, and looks at first sight like a stoutly built grass. But it is in reality a relative of adder's-tongue and moonwort, and if, during the summer, we examine the inner sides of the bases of its leaves, we shall find that each of them bears a comparatively large spore-case. As in all the water-ferns, these are of two kinds, which respectively contain small spores and large spores, and having regard to the fate of these we may call the leaves which produce them *male spore-leaves* and *female spore-leaves.* For a small spore germinates to produce a minute male prothallus with a single sperm-organ, while a female spore gives rise to a rather larger female prothallus, which bears a few egg-organs.

Of the remaining members of this group, which are more nearly related than quillwort to ordinary ferns, the first to be considered is salvinia [193], a small aquatic plant, native to South Europe. It is entirely devoid of roots, and consists of a stem bearing two kinds of leaves, some being oval and floating on the surface, while the others are finely divided and submerged. The latter play the part of roots, and they are also fertile, for at their bases are found rounded sori containing large-spore and small-spore cases. The spores germinate within these in much the same way as in quillwort.

Marsilia [194] grows in marshy ground, and is represented by European and Australian species. There is a creeping stem, from the under side of which roots are given off. The long-stalked leaves fork into a sterile and a fertile portion, the former terminating in a blade which is divided into four parts, and somewhat suggests wood-sorrel in general appearance. The fertile section ends in a hard, bean-shaped structure, which may be called the *spore-fruit*, and contains a number of spore-cases, of which some enclose large and others small spores. When these are ripe, part of the internal tissue of the fruit is converted into mucilage, which swells up and splits open the firm investments along one side. The spores now germinate to give rise to the two kinds of prothallus, and the fertilised egg-cells grow into new plants.

Pillwort (*Pilularia*) [195] grows in the same kind of places as the last-named plant, and is a European species occurring in Britain. It possesses a creeping stem with roots, and narrow leaves. Parts of their bases are modified into rounded, brown spore-fruits, the shape of which has suggested the popular and scientific names. These contain a number of spore-cases of both kinds, which are liberated by the swelling up of mucilage, that bursts open the fruit in a valvular fashion. The rest of the life-history is much the same as in marsilia.

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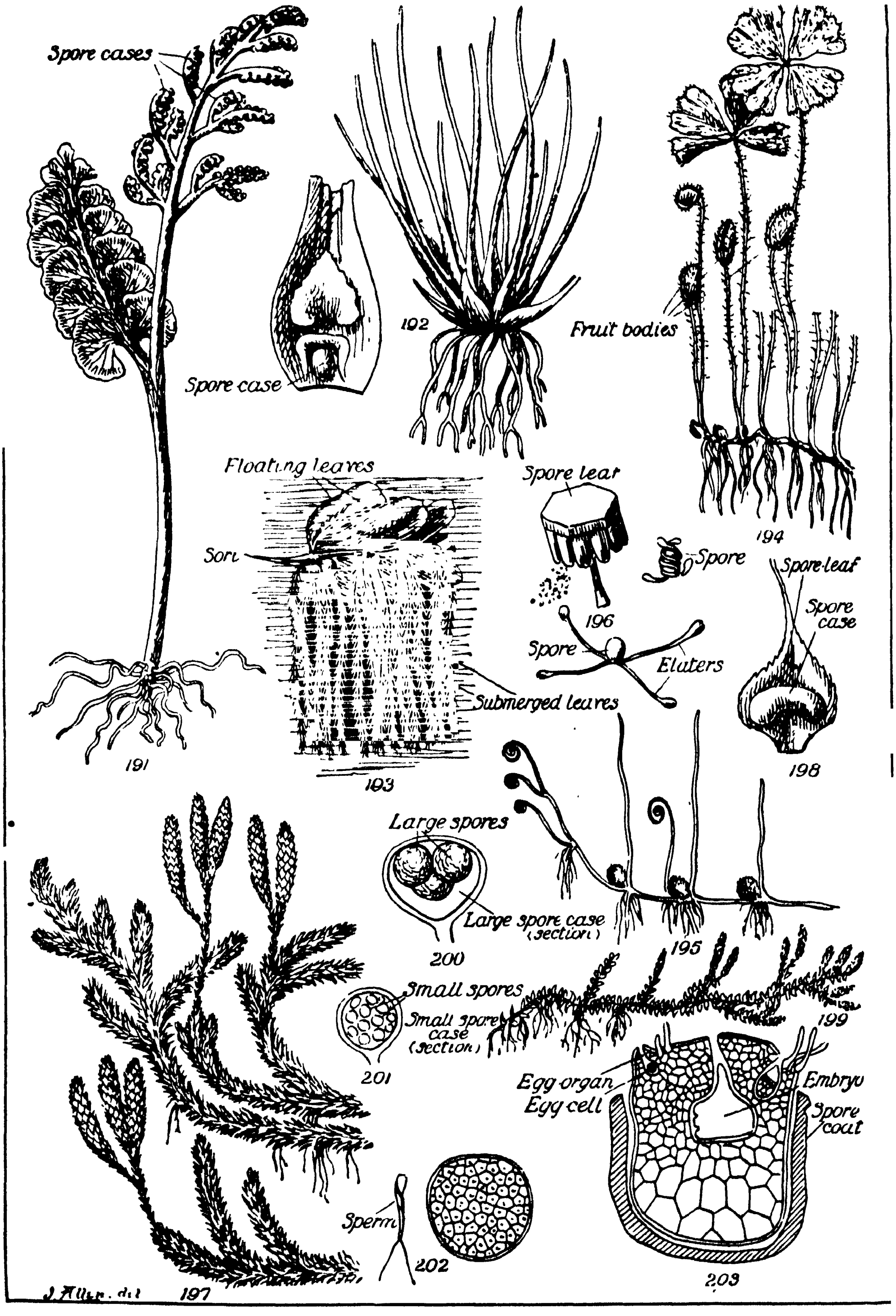


191. Moonwort. **192.** Quillwort. **193.** Salvinia. **194.** Marsilia. **195.** Pillwort (Pilularia). **196.** Horsetail. **197—8.** Club-moss. **199—203.** Selaginella. **202.** Male prothallus (section). **203.** Female prothallus.

PRELIMINARY TREATMENT OF WOOL

Wool Sorting: its Theory and Practice. The Processes of Steeping, Scouring, Drying, Teasing, Opening, Burring, Oiling, and Blending

By W. S. MURPHY

Wool in the Store. Wool comes to the factory in bales weighing about 400 lb., and containing from 70 to 90 fleeces, according to the size and weight of the single fleece. We expect to find 70 or more fleeces in a Saxony bale, about an equal number in an Australian, and 80 to 90 in a Cheviot bale. We have reviewed the broad field of wool supply and noted the numerous varieties of wool; but in each one of those varieties another division must be made. One sheep, in the course of its existence, can produce four distinct classes of wool. These classes are: (1) Lamb wool; (2) yearling, or hogget; (3) ewe, or wether; (4) skin, or pelt. For lamb wool the lambs are shorn at the end of the season in which they have been born; hogget or yearling is taken off the year after; wether wool is obtained from the sheep in the years following; pelt wool is derived from the skin of the dead sheep. Class 1 is finest but short; class 2 is the best crop, being long and almost as fine as lamb; class 3 is the medium quality; class 4 is wholly inferior, the wool being in all stages of growth.

Theory of Wool Sorting. Before undertaking to deal with the fleece, we must clearly define our intention. Wool sorting is one of the few skilled handicrafts left in the factory. The sorter's work can never be done by any machine, because every sheep grows on its back qualities of wool differing very much, and those qualities are separable only by the skilled observer. From a single fleece fine sorters are required to pick out as many as fourteen different qualities of wool. It will be obvious that close observation, a quick eye, and deft hands are needed for the work.

Old-fashioned factories still retain the technical names for the various sorts now distinguished by numbers, woollen and worsted workers having their own special terms. The terms of the woollen sorts are: *Picklock* (fore shoulder), choicest in fineness of fibre, elasticity, and strength of staple; *Prime* (middle of body), only slightly inferior; *Choice* (back), true, but not so fine in fibre as prime; *Super* (loin), not so valuable as choice, but similar in general properties; *Head*, inferior sorts of wool derived from that part of the sheep; *Downrights*, derived from the lower sides; *Seconds*, from the throat and breast; *Abb*, the skirtings and edgings of the fleece; *Breech*, short, coarse hair from the hinder parts.

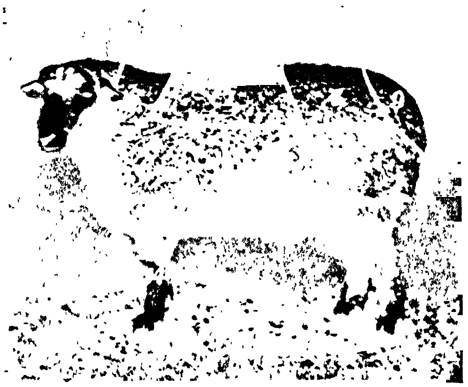
Worsted men have this classification: *Blue*, from the neck; *Fine*, from the shoulders; *Neat*, from the middle of the sides and back; *Brown-drawing*, from the haunches; *Britch*, from the tail and hind legs; *Cow-tail*, when the breech is very strong; *Brokes*, from the belly and lower part of the front legs, classed as *super*, *middle*, and *common*, according to quality.

The theory on which sorting is based involves an important assertion, founded on experience. Our assertion is that wool taken from the same place in fleeces of the same quality will be found equal in every respect for practical purposes. The value of that idea can hardly be estimated. We can get only a small quantity of wool of one quality from one fleece. Even if a whole fleece were of one quality, a single fleece does not make a web of cloth, and fleeces differ greatly. By adopting this principle, we get a number of uniform qualities of wool from each fleece, and the same qualities from an endless number of fleeces of the same kind.

34. WOOL SORTING (ENGLISH FLEECE)

Scientific Sorting. With such a wide range of material upon which to work, the sorter has not the power to obtain complete uniformity of treatment; but the trade has adopted two modes of classification which fairly cover all practical needs. The one method is generally used for British breeds, and the other for Merinos and similar kinds. Let us take the stronger class first [**34**].

1. *Shoulder.* Long and fine wool, growing close and even.
2. *Side.* Stronger, but otherwise equally good.
3. *Neck.* Short, but fine, liable to be mixed with greyish wool.
4. *Back of neck.* Inferior.
5. *Top of fore shoulder.* Faulty and irregular, but of medium quality.
6. *Loins and back.* Rather coarse and short, but fairly true in character.



35. WOOL SORTING (MERINO FLEECE)

7. *Middle of haunch.* Long strong wool of large staple

8. *Hinder parts.* Coarse and long, apt to be hairy.

9. *Top of hind leg.* Very like 7, but rather dirtier.

10. *Under body.* Short, dirty, but fine towards the fore legs—known as " brokes."

11. *Top of fore leg.* Short and fine.

12. *Throat.* Irregular, short, and kempy.

13. *Head.* Short, rough and coarse wool.

14. *Shanks.* Rough, hard wool, of little value.

The division of the Merino fleece has been best described by Dr. Bowman, and, with a few modifications, we adopt his scheme [**35**].

1 and 2. *Shoulders and sides.* The wools grown on these parts are remarkable for length and strength of staple, softness of feel, and uniformity of character. They are usually the choicest wools found in the fleece.

3. *Lower part of back.* This is also a wool of good, sound quality, resembling in staple that obtained from the shoulders and sides, but not so soft and fine in fibre.

4. *Loin and back.* The staple here is comparatively shorter, and the hair not so fine, but the wool on the whole is of a true character. In some cases, however, it is rather tender.

5. *Upper parts of legs.* Wool from these parts is of a moderate length, but coarse in fibre, and possesses a disposition to hang in loose, open locks. It is generally sound, but liable to contain vegetable matter.

6. *Upper portion of neck.* The staple of the wool clipped from this part of the neck is wholly of an inferior quality, being faulty and irregular in growth, as well as full of thorns, twigs, and other matters.

7. *Central part of back.* This wool closely resembles that obtained from the loins and back, and is rather tender.

8. *Belly.* This is the wool found on the under parts of the sheep, between the fore and hind legs. It is short, dirty, and poor in quality, and somewhat tender.

9. *Root of tail.* Fibre coarse, short, and glossy, and very often the wool is mixed with kemps or hairs.

10. *Lower parts of legs.* Most of this wool is dirty and greasy, the staple lacking curliness and the fibre fineness. It is usually full of burrs and vegetable matter.

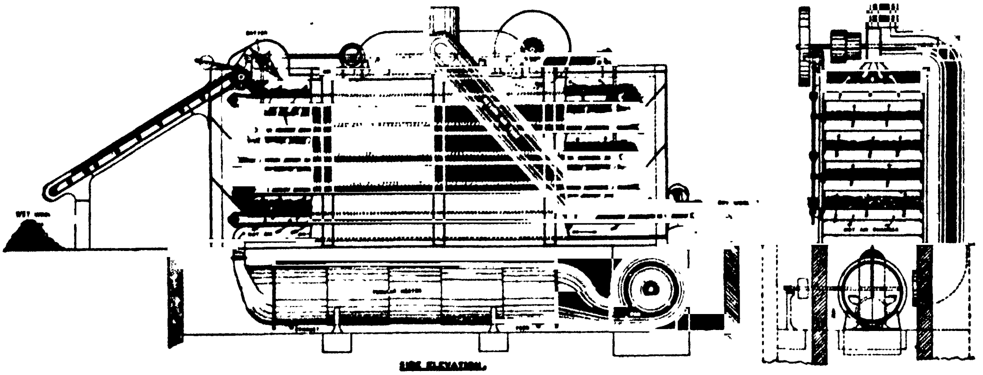
11, 12, 13. *Head, throat, and chest.* The wools from these parts are generally classed together, as having the same characteristics. A small portion of fair wool may often be got from the chest. The fibre as a whole is stiff, straight, and coarse, mixed with fodder, and kempy.

14. *Shins.* This wool is short, straight, and stiff, and of little value.

Practical Sorting. When unpacked from the bale, the wool is full of all kinds of dust and dirt. The best kind of sorting bench is made of a wooden frame enclosing a table of

36. WOOL SCOURING

woven wire, the smooth surface of which gives an even base to the fleece, while the meshes let through the dust and rubbish, which is drawn away by exhaust fans, through a wide tube, to the dust-pit. Lift the fleece flat, and lay it wool side undermost on the bench. Set the wool baskets round, those for the highest qualities nearest to the hand. Now take the big clipping shears, and remove adhering skin, tar-marks, rough edges, clogs, and other excrescences; then shear the fleece into two halves. Lay the half, wool side up, across the bench, head and tail, and sort out the various qualities, following the one table or the other, according to the kind or quality of fleece. In gripping, see that you take the wool away clean, because in some parts the quality of wool very suddenly alters from low to high, and mixing is fatal.



87. WHITELEY'S DRYING APPARATUS

Wool Steeping. High-class fleeces, such as Saxony and fine Botany, may be sent direct to the scouring machines; but we are engaged chiefly on stuff that is not first-class. All wools of average quality are usually very dirty, and the wool manufacturer is prudent who makes provision for steeping his wools before scouring. Steeping is a very simple operation, the object being to take away the rough dirt and to soften the matted staples. Various methods of steeping have been adopted, the simplest being a bath with a perforated double bottom, with wide meshes, which let the dirt fall through to the bottom of the bath and retain the wool. When the wool has been steeped long enough, and the water let off, it is roughly dried by being passed between a pair of rollers The best steeping arrangement we have seen is highly ingenious, and so contrived that the water penetrates the mass of wool from below, and maintains a circulating motion. These machines are easily managed, and require no detailed instructions.

Wool Scouring. This is one of the most important operations in the preparation of wool, and calls for detailed attention. Many a blemish has appeared in yarn which remained a mystery till the explanation was found in the scouring troughs. Two facts must always be kept in mind by the wool scourer—first, that a detergent acts chemically, for the most part; and, secondly, that wet wool felts and knots very readily. Simple as these facts appear, they have not been acted on by many would-be inventors of scouring machines. Taking a model from the domestic washing-tub, it has seemed to them a splendid thing to produce a scourer that would make a lot of splash and soapy suds, not knowing that wool splashed about gathers into knots and strings no man can unravel. The aim of the scourer is to permeate the wool with an effective detergent, with as little movement as may be possible. He must, of course, use a machine, and we should find one which will economise scouring ingredients, take the wool through comparatively free and open, let away the dirt readily, and deliver a clean wool at the end.

A good many scouring machines have been invented, but the model most generally used [86] is a combination of forks or pikes working the wool through a series of troughs filled with scouring liquor. Let us suppose that we have a scouring machine 60 ft. long and over 6 ft. broad, divided into three troughs by movable compartments, in which are perforated false bottoms 6 in. above the real bottoms. Hung horizontally across the troughs are rows of long forks, automatically moved by gearing in the sides of the machine, and between each trough a lifting and squeezing apparatus for transferring the wool from one trough to the other. This machine will do fairly good work, but it must have the proper ingredients to work with.

Scouring Liquors. Water is the vehicle of our detergent, but the detergent itself may be potash, carbonate of soda, silicate of soda, ammonia, or soap. Carbonate of soda gives a harsh feel to the wool; silicate demands a good deal of careful sousing, to clear out the hard silicate; and ammonia is very nice, but rather weak for most wools. We advise the following: First trough, 6 gallons potash soap mixed with pearlash; second, three gallons potash soap and pearlash in small proportion; third, pure, warm water. For coarse wools the water should be of a heat ranging from 90° F. to 130° F.; for finer wools, from 120° F. to 142° F. The gradation is from strong liquor to pure water. As the strong liquor trough receives the wool first, it must become foul first, and it has been found a profitable plan to empty the strong liquor out when it has become too dirty, run the second trough into the first, and the third trough into the second, make up the first and second to the required strength, and fill the third again with pure water. This method economises potash, water, and labour.

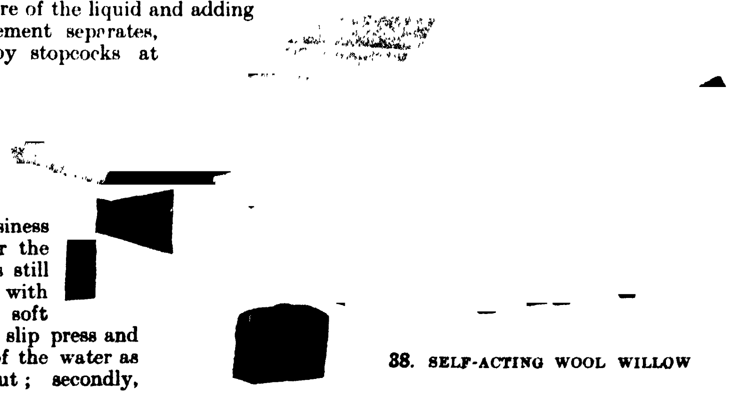
Scourer at Work. Having got the machine into working order, we put the wool on a feed-lattice that bears it forward into the strong scouring liquor, and there it is waved gently to and fro, while being brought along inch by inch—the liquor sapping through it meanwhile—to the end of the trough. Here the wool is automatically lifted on to a board, and drawn between two heavily clothed rollers, which gently press out the superfluous liquor, and drop it into the second trough. Ingeniously devised buckets, like elevators, catch the squeezed liquor and lift it back into the first trough. Through trough number two the wool makes the same slow and steady progress, and then is plunged into the warm-water trough, in which it is gently soused free from cleansing liquor, to be firmly squeezed in the drying rollers. Thence the wool must be taken to the drying apparatus.

Utilising Waste Scour Liquors. Analysis of raw wool shows that one-third of the weight of raw wool is made up of yolk and grease. In the scouring process this substance falls to the bottom of the scouring-trough, and impregnates the scouring liquid. When emptying the trough, we simply pour the whole lot—waste liquor and residuum—into large settling tanks. From the first settling tank, in which the hard dirt drops away, the liquor is pumped up into the highest of a series of settling tanks. Here the liquid is scoured by the addition of sulphuric acid, and heated by the injection of steam. The acid separates the grease from the soda, and three distinct layers form in the tank—the grease on the top, the water and suspended acid and soda, and a mixture of earthy matters and grease at the bottom. From the surface the grease is skimmed off, and the rest of the contents run down into the tank below, where the process is repeated. Here, however, we make an effort to recover our scouring acid, and succeed by raising the temperature of the liquid and adding more acid. Each element separates, and is drawn off by stopcocks at different levels in the side of the tank. The recovered potash can again be utilised in the troughs

Having got the grease, our next business is to make it fit for the market, because it is still dirty and mixed with water. First, the soft masses are run into a slip press and freed from as much of the water as can be squeezed out; secondly, the grease is transferred to the hot press, in which, under steam, the oily substance is melted out, and escapes into a tank, where it is taken possession of by the purifiers, who ladle it up into a lead-lined vessel, search it thoroughly with strong sulphuric acid for remaining traces of water, and then barrel it for sale under the name of "Yorkshire grease." In all this we exhibit the principle only of utilising the liquors; the methods are various.

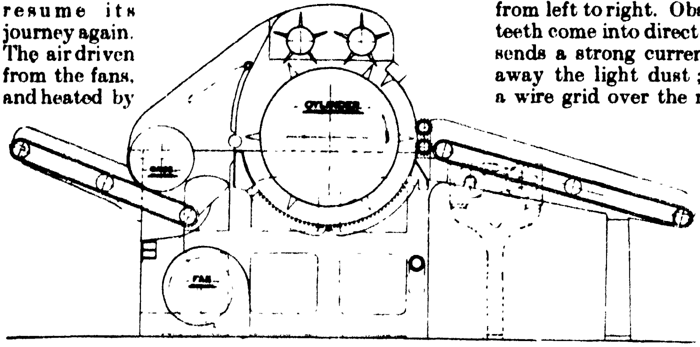
Drying Wool. Before wool can be taken a step further it must be thoroughly dried; all our machinery presupposes a perfectly dry material. Two drying machines are commonly used, though some factories have drying rooms specially fitted up on principles almost as varied as the number of them permits. The older machine is a roof-like wire frame, within the triangle of which are two sets of fans on revolving spindles, and two pairs of hot steam pipes. In the apex of the roof are two funnels. On the wire sides of the frame the wet wool is laid in an even layer. Steam is sent into the pipes, and the fans set revolving. As they revolve the fans cause the air to circulate down through the funnels, round the hot pipes, and up through the wool. Theoretically, it seems all right; but in practice the machine has defects, especially in work requiring speed and uniformity. For one thing, the lower fibres get an undue share of both heat and air

A West of England man named Moore, experiencing the defects of the machine described, invented the newer one. It is a highly ingenious contrivance, though rather elaborate. Picture a large box, with doors at each end and two funnels from the top leading out to the roof, and there crowned by exhaust fans. Such is the external aspect of this dryer. Having our wet wool ready, we open the fore-end door, and see inside a long row of rollers revolving transversely between a double series of steam pipes, one series above and the other below, and above the higher range of pipes another row of revolving rollers. At the far end, its spiked rims almost touching the whole structure, turns a huge wheel.



38. SELF-ACTING WOOL WILLOW

We feed in the wool, and it travels like a fluffy snake along the lower row of rollers, to be dragged off and cast up on to the row of rollers above by the swiftly running wheel. The action of the top rollers brings the wool back along the length of the machine, and it drops down at the near end to resume its journey again. The air driven from the fans, and heated by the steam pipes, makes a warm draught of air go through the travelling wool. Sufficiently dry, the wool must now be freed from the circle. For this purpose, the door at the back of the machine is opened, and the flinging action of the wheel throws the wool outwards on to the floor. The batch of wool may weigh 100 lb., and the time taken is about 20 minutes. The side elevation and cross-section of a new and improved model of this machine, made by Messrs. Whiteley & Sons, Limited, of Lockwood, are shown in 37.



39. SECTION OF WOOL WILLOW

Teasing Wool. The clinging properties of wool are very convenient in making threads; but we find these very qualities rather troublesome in the raw wool. Crinkled and serrated, the fibres hold together in tufts, and no amount of scouring can effect a separation. But parted they must be, or we can make no yarn. Each fibre, indeed, should be singled out and put into its place. When it is considered that 4,000 fibres of fine merino wool can grow on a square inch of skin, the intricacy of the mixing may be imagined. For picking out and separating the combined fibres we have a long series of machines, graduating from a simple tearing apart to the detailed direction of the individual fibres toward their places in the long filaments we name yarn.

Opener. Our first wool-teaser is called the *opener*, and it resembles closely a machine of the same name used in the cotton factory, although the two are distinct and call for separate description. Several makers have put forward new and, in some cases, improved openers, but after we have learned to work the ordinary machine, the others will present no difficulty. The working part of the opener [38] is hidden under its strong iron casing, but we must look under the iron [39]. In the centre is a large cylinder, and above it two small cylinders. Along the large cylinder iron bands are fixed, and from each band spring two rows of curved teeth. On the little cylinders we see long iron spikes set like formidable teeth in the jaw of a terrible monster. By giving the wheels a turn we can observe how these things work. The motion of the large cylinder is quicker than that of the small ones, and the movement of the former is from right to left, while the latter turn from left to right. Observe, also, that none of the teeth come into direct contact. A fan at the back sends a strong current of air through, drawing away the light dust; beneath the cylinders is a wire grid over the receptacle for refuse. The creeper band in front completes the machine.

Lattice Creeper. Before going further, let us explain the feeding contrivance constantly used in many textile machines, and often referred to, but seldom described. If you lace a number of flat strips of wood together so that they form a band, join the ends, and stretch over two rollers, you have what we call an endless lattice band or creeper. Obviously, if the rollers revolve, the band will move forward, and anything placed upon it must also be borne in the same direction. This is the feeding apparatus on most textile machinery.

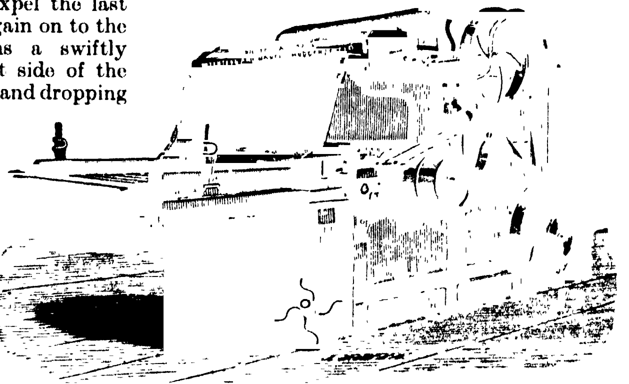
Opener at Work. Pile the dried wool on the lattice creeper, and set the machine going. As the wool comes through the fluted feed-rollers, the curved teeth of the cylinder bear it away; but the little cylinders slowly turn above, and pick the wool out of the teeth of their big neighbour with their long spikes. As the large cylinder travels at ten times the speed of the small ones the pull between them is very great; yet, because the one set of teeth does not enter the plane of the other, there is no positive drag, the cylinders parting, as it were, the tufts between them in an amicable spirit of division. Thus the tangled locks of wool are opened out, and at the same time, by the beating, dragging, and whirling, combined with the blowing of the fan, the dust yet adhering to the fibres is driven out.

Burring. Fed among grass and quick-seeding plants of various kinds, sheep gather in their coats an incredible quantity of those clinging, prickly seeds described comprehensively as burrs. Scouring and opening do not clear the wool of these things, and many of us have been seriously puzzled to discover what would. Leave but a few fragments of those insidious little seeds in, and they will appear in the finished cloth as a surprising multitude of pins, almost invisible, but horribly sharp. Two methods are adopted, and both are admittedly imperfect, for opposite reasons. One is what is called the extract method, in which sulphuric acid is used to destroy all vegetable matters; it is effective, but the texture of the wool is deteriorated. The other method is mechanical, by means of the burring machine

[40], and this is admittedly defective in that it does not infallibly clear out all the fragments of seeds, but it has the merit of preserving the quality of the wool and forwarding the manufacturing process. When we deal with the utilisation of waste, the chemical method of treating wools for burrs will be detailed at length. At present we proceed with the mechanical method, which is in the direct line of our advance in preparing the fibres.

Burring Machine. If any machine was ever devised with strict attention to the end in view, it is the burring machine. Every part of the contrivance is directed to two purposes, one to disentangle the fibres, and the other to throw up the burrs so that they can be cleared off easily. On this account alone it is worthy of detailed study. In front there is the usual feed-lattice, which carries the wool forward to the two fluted feed-rollers, and beyond, quite inside the machine, is the licker-in, or revolving fan. The latter merely beats the wool down on a travelling lattice-sheet within the machine, which carries it onward to where a roller-brush is running, and this swiftly revolving brush lifts the fibre on to the central cylinder armed with needle-pointed steel plates, presenting serried rows of small teeth. Borne swiftly round on the central cylinder, the fibres come in contact with the two spiral-bladed burr rollers and the ledger blades, which, acting and reacting, open out the wool and draw off the burrs. Thence the loosened fibres are taken by a large roller and beaten firmly against a grid, to expel the last few clinging particles, and let off again on to the large cylinder, behind which runs a swiftly driven brush, always keeping that side of the cylinder clear, cleaning off the wool, and dropping it into the box at the end of the machine.

Blending. The wool is now ready for blending. We saw at the sorting bench how a single fleece yields fourteen different qualities of wool. By supposition, however, all this batch of wool we have been treating has been taken from one sorting number—say, Number 1, Botany, or Australian merino. This makes our task of blending a comparatively easy, but by no means a superfluous, operation. Select and breed your sheep ever so carefully, each sheep will have its own individuality and peculiarities. Superficially regarded, the members of a flock of sheep appear very much alike; but if you watch a shepherd at work, you will be astonished to discover that he knows nearly every individual sheep. Careful examination of the wool before us will enforce the same lesson. Though belonging to the same class, those wools differ in a marked degree, and no ingenuity of selection can alter the fact. It is a well-known fact that by combining differences an average is produced. That is the object of blending.



40. BURRING MACHINE

At this point, however, some words of explanation are necessary. If there were no such entities as money and markets, our procedure would be unchallenged. If every kind and class of wool were used unmixed to produce the yarn and class and kind of fabric for which it is best suited by nature, textile manufacture would be a much easier profession than it is. There are many blends, which may be roughly classed under these heads: (1) Different wools; (2) wool and silk; (3) wool and cotton; (4) wool and bast fibres, such as flax, hemp, and jute; (5) wool and waste fibres, such as noils, shoddy, mungo, and extract.

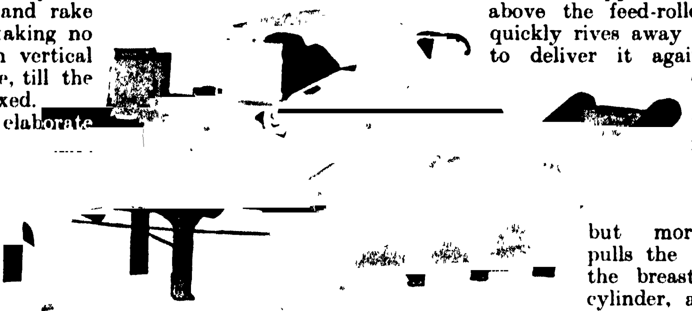
Mixed Wools. The main reason for mixing wools is the compulsion put upon manufacturers to produce given counts of yarn at low prices. The fluctuations of the raw wool market largely affect the wool-blender's work. When New Zealand wool was selling at 4¾d., in 1895, the temptation to mix in lower class wools was small; but when the average price rose to over 8d., the position became wholly different On that side it is impossible to be definite; every season brings its own peculiar problems. But in regard to the wools themselves clear rules must be observed. In our table of wools we have given the highest counts of yarn into which the various wools can be spun. The finest of fine Leicester cannot be spun to a higher count than 70, and most manufacturers consider 50 as high as should be attempted. To mix that wool in for a higher count of yarn is to fail. The safe rule is to blend nearly related wools of similar character—soft with nearly soft, fine with fine medium, carding with carding, and combing with combing wools

Wool and Silk. Before being brought to the blending-room the silk waste should be thoroughly prepared. It is perhaps most important to see that the length of the silk fibres does not too greatly exceed that of the wool staple. Next to that is the question of colour, the silk, in the case of mixed colours, always making part of the ground or main body.

Wool and Cotton. For a long time theoretic difficulties were constantly being raised to this mixture, while actual practice showed good results Coarse wools cannot combine with cotton, because there is not in cotton a corresponding weight or thickness of fibre. Very fine, short wools, such as the best merino, mix well with cotton. Equal quantities of both fibres produce the best results, and the blending should be very intimate.

Practical Blending. Wool blending is a hand process, for the most part. The wool is spread out on the floor in thin layers, one layer above the other, till the whole batch stands a square mass. The wider the differences in the mixture, the thinner should be the layers, so that the mixing may be more intimate. Now take a fine rake and rake down the stack, taking no more than a thin vertical slice at each stroke, till the whole has been mixed.

Other and more elaborate methods are often adopted; but, as we have broadly hinted, these relate to blends and theories of blending far beyond the scope of our study.


41. COCKSPUR TEASER, WITH OILING APPARATUS

Oiling. When scouring the wool, we deliberately took from it the natural oil or grease, and now it is so bare and harsh that we cannot make much use of it. In the machines used up to this point the fibre has been treated gently, tearing and severe dragging being particularly avoided. But wool cannot be formed or made into yarn by such soft persuasions. We must put it through the scribbler, at least, whose myriad teeth will drag and pull with vicious insistence. Those scaly serrations, upon which so much of the value of the fibre depends, must, left bare, be broken and torn. Olive-oil is the best and, we believe, finally the cheapest lubricant for wool.

Oil Spraying and Teasing. The "Fearnought" [41] is worthy of special note, because it is the first and simplest of that class of machines named carders, with which we shall have a great deal to do. By carefully observing this contrivance we prepare ourselves for understanding the more complex carding machines. In main structure the "Fearnought" consists of an iron frame supporting a feed-lattice, a central cylinder, a series of small rollers revolving over the cylinder, and a fan cylinder at the end. Let us examine the relations and character of these.

On the surface of the large cylinder spikes, shaped like dog's teeth, form diamond squares about an inch in area, and similar teeth are on the small rollers, while two rows of straight teeth stick out from the edges of the wings of the cylindrical fan Note now the rollers: they alternate large and small, the large being called workers and the small the strippers. All the workers are geared together, and a separate gearing connects the strippers, the latter being required to revolve much more quickly than the former, for reasons we shall understand presently. Over the fore-end of the machine is the oiling apparatus, with oil cistern and spraying distributor, efficiently controlled from the machine.

Lay the blended wool on the feed apron. As it moves slowly forward in a thin layer, the spray of oil passes over it like a softening vapour, and the wool is drawn in by the feed-rollers, the lower one of which faithfully presents the fibres to the large cylinder, while the upper one, like a greedy agent, wraps a portion of the stuff round itself But a stripper roller is geared above the feed-roller, and it quickly rives away the spoil, to deliver it again to the cylinder. Another worker roller, revolving in the same direction, but more slowly, pulls the wool from the breast of the cylinder, and winds it round itself. Once again a stripper ally of the big, spiky wheel interferes, digs its long teeth into the teeth of the worker, and, being driven at greater speed, pulls away the wool and swiftly surrenders it to the cylinder. Thrice the triple action is repeated, worker, stripper, and cylinder drawing and teasing out the wool and at the same time making the mixing more intimate.

Meanwhile the fan is doing its double work, driving with its swiftly flying blades all the remaining dust out of the fibres, and at the same time doffing the teased wool from the cylinders with the straight teeth fixed on the edges of its flanges or wings, and throwing it into the receptacle.

Three principles are at work here, and can be more easily viewed in this simple machine than in any other. First, there is the principle of directly opposed force, which is probably the first movement in mechanical effort. All hand tools are simple examples of the principle. But instead of acting as one of the opposing forces, the wool manufacturer gets three sets of power-driven rollers to do it for him. The second principle is differential motion, by which bodies moving in the same direction at different speeds react upon each other or on the agent between them, such as the wool in the present instance. The third principle is that of centrifugal force, the magnetic power developed by the revolving bodies causing the wool to cling and remain within the little round prescribed.

Continued

INTEREST AND DISCOUNT

Interest, Simple and Compound. Present Worth and True Discount. Bills of Exchange and Commercial Discount

Group 21

MATHEMATICS

8

Continued from page 1000

By HERBERT J. ALLPORT, M.A.

INTEREST

120. If a person borrows money, he usually pays something for the loan. The sum of money he borrows is called the *Principal;* the money he pays for the use of the principal is called *Interest.* Interest is generally reckoned at so much for the use of each £100 for one year. This amount is called the *Rate per Cent. per Annum.*

Thus, if we say that £200 is borrowed for three years at 4 per cent. per annum, we mean that the borrower, at the end of each year, pays the lender £4 for each £100 borrowed—*i.e.*, £8 interest for each year.

In the above example, where the interest is supposed to be paid to the lender at the end of each year, it is clear that the interest is proportional to the number of years—that is, the interest for two years is twice the interest for one year, the interest for seven years is seven times that for one year, the interest for one month is $\frac{1}{12}$ that for one year, and so on. Interest thus reckoned is called *Simple Interest.*

If, however, the interest at the end of the first year is unpaid, it is added to the principal and thus forms a new principal for the second year. Consequently, the interest for this second year will be more than the interest for the first year. When the interest is added, year by year, to the principal, as it becomes due, the money is said to be lent at *Compound Interest.*

The sum obtained by adding the interest for any given time to the principal is called the *Amount* in that time.

121. Suppose we have to find the simple interest on £420 for three years at 5 per cent. per annum. We can obtain the result by means of "compound proportion."

(i.) We are required to find *interest.* Hence, £5, the *interest* on £100 for one year, will be the third term of the proportion.

(ii.) We next ask, "If the interest on £100 is £5, will the interest on £420 be more or less?"—whence we obtain the ratio £100 : £420.

(iii.) "If the interest for one year is £5, will the interest for three years be more or less?"—giving the ratio 1 year : 3 years.

Thus, the statement is:

$$\left.\begin{array}{l}£100 : £420\\ 1\text{ yr.} : 3\text{ yr.}\end{array}\right\} :: £5 : \text{Required Interest.}$$

$$\therefore\ \text{Interest} = \frac{£5\times420\times3}{100}.$$

Hence, we see that

$$\text{Interest} = \frac{\text{Principal}\times\text{rate}\times\text{time (in years)}}{100},$$

or, in other words, ***to find the simple interest multiply the principal by the time expressed in years, and by the rate per cent., and divide the product by*** 100.

Example 1. Find the Simple Interest on £162 10s. for four years at $3\frac{1}{2}$ per cent.

$$\text{Interest} = \frac{£162\frac{1}{2}\times4\times3\frac{1}{2}}{100}.$$

$$= \frac{\overset{13}{\cancel{325}}\times\cancel{4}\times7}{\cancel{2}\times\cancel{2}\times\underset{4}{\cancel{100}}} = £\frac{91}{4} = \underline{£22\ 15s.\ \textit{Ans.}}$$

Sometimes it is more convenient to arrange the work as follows:

Example 2. Find the amount of £345 15s. 4d. in 15 months at $2\frac{1}{2}$ per cent. Simple Interest.

£	s.	d.
4)345	15	4
86	8	10
2)432	4	2
		2
864	8	4
216	2	1
£10,80	10	5
20		
16,10s.		
12		
1,25d.		
4		
1,00f.		

EXPLANATION. 15 months = $1\frac{1}{4}$ years. Write down the principal, and add one-quarter of it, giving £432 4s. 2d. Multiply this result by $2\frac{1}{2}$, giving £1,080 10s. 5d. Divide by 100 [Art. **25**]. Thus, the interest is £10 16s. $1\frac{1}{4}$d., and Amount = Interest + Principal.

	£	s.	d.
∴ Interest =	10	16	$1\frac{1}{4}$
Principal	345	15	4
∴ Amount =	£356	11	$5\frac{1}{4}$ *Ans.*

122. Since, Interest = Principal × Rate × Time ÷ 100, it follows that if we are given any three of the four quantities—interest, principal, rate, time—we can find the fourth quantity. In the last article we considered the case in which interest was the quantity to be found. We shall now work examples illustrating the other three cases—*viz.*, to find the rate, to find the time, and to find the principal.

Example 1. At what rate per cent. will the Interest on £175 for 4 years amount to £24 10s.?

Either, by proportion, find the interest on £100 for 1 year (which is the required rate), knowing that the interest on £175 for 4 years is £24 10s. Thus

$$\left.\begin{array}{l}£175 : £100\\ 4\text{ yr.} : 1\text{ yr.}\end{array}\right\} :: £24\ 10s. : \text{Required Rate.}$$

$$\therefore\ \frac{\overset{7}{\cancel{49}}\times\overset{4}{\cancel{100}}}{2\times\underset{7}{\cancel{175}}\times\cancel{4}} = \underline{3\tfrac{1}{2}\%\ \textit{Ans.}}$$

Or, find the interest on £175 for 4 years at 1 per cent. and divide the result into the given interest. Thus—

Interest on £175 for 4 years at 1 per cent.

$$= \frac{175 \times 4}{100} = £7.$$

$$\therefore \text{ Required rate} = \frac{£24\tfrac{1}{2}}{£7} = \underline{3\tfrac{1}{2}\% \ \textit{Ans.}}$$

Note. If we are given the *amount* instead of the *interest*, we must first find the interest by subtracting the principal from the amount and then proceed as above.

Example 2. In how many years will £175 amount to £199 10s. at 3½ per cent.?

Here, interest = £199 10s. − £175 = £24 10s.

We now find the interest on £175 for 1 year at 3½ per cent. and divide the result into the given interest.

Interest on £175 for 1 year at 3½ per cent.

$$= \frac{£175 \times 3\tfrac{1}{2}}{100} = \frac{7 \times 7}{2 \times 4} = £\tfrac{49}{8}.$$

$\therefore$ Required number of years

$$= £24\tfrac{1}{2} \div £\tfrac{49}{8},$$

$$= \frac{49}{2} \times \frac{8}{49} = \underline{4 \text{ years} \ \textit{Ans.}}$$

Example 3. Find the Principal which will amount to £199 10s. in 4 years at 3½ per cent.

The interest on £100 for 4 years at 3½ per cent. = 4 × 3½ = £14.

$\therefore$ £100 is the principal, which amounts to £114 in 4 years at 3½ per cent.

Hence we have the following proportion :

£114 : £199 10s. :: £100 : Required Principal.

$$\therefore \text{ Required Principal} = \frac{£100 \times 199\tfrac{1}{2}}{114}.$$

$$= \frac{\overset{25}{\cancel{100}} \times \overset{7}{\cancel{399}}}{\cancel{2} \times \underset{2}{\cancel{114}}} = \underline{£175 \ \textit{Ans.}}$$

If we are given the interest, instead of the amount, we proceed in the same way—*i.e.*, we find that the interest on £100 for 4 years at 3½ per cent. is £14, and then we know that £14 : Given Int. :: £100 : Reqd. Principal.

123. If the time, for which the interest is required, is from one given date to another, such as "April 12th to July 14th," we do not count the first of these days. In the case just mentioned, interest would be reckoned for 30 − 12, *i.e.*, 18 days of April, 31 of May, 30 of June, and 14 of July, making a total of 93 days.

124. Compound Interest. From what has already been said about Compound Interest it is plain that we find the Amount in any given time by calculating the Simple Interest for each year in succession, the Principal, of course, becoming greater in each succeeding year. The Compound Interest for the whole period will be the difference between the Amount and the original Principal.

The work can be more compactly arranged by using £'s and decimals of a £, than by using £ s. d.

Example. Find the Compound Interest on £1375 for 2 years at 3 per cent.

$$\begin{array}{r l}
£1375 & = \text{1st year's Principal.} \\
41{\cdot}25 & = \quad ,, \quad \text{Interest.} \\
\hline
1416{\cdot}25 & = \text{2nd year's Principal.} \\
42{\cdot}4875 & = \quad ,, \quad \text{Interest.} \\
\hline
1458{\cdot}7375 & = \text{Amount.} \\
1375 & \\
\hline
£83{\cdot}7375 & = \text{Total} \\
20 & \\
\hline
14{\cdot}7500\text{s.} & \\
12 & \\
\hline
9{\cdot}000\text{d.} & \\
\end{array}$$

$$\underline{£83 \ 14\text{s.} \ 9\text{d.} \ \textit{Ans.}}$$

Explanation. To find the interest for 1 year at 3 per cent. we multiply £1375 by 3 and divide by 100. Hence our second line is obtained by multiplying 1375 by 3 and moving the digits two places to the right. Then, adding 41·25 to 1375, we get £1416·25 for the second year's principal. We now repeat the process—*i.e.*, multiply 1416·25 by 3 and move the digits of the product two places to the right. This gives 42·4875 for the second year's interest. Add this to the second year's principal, and we obtain the Amount. Subtract the original principal, and we have £83·7375 for the Compound Interest. The £·7375 is reduced to shillings and pence, as in Art. **91**, Ex. **3**.

125. Before proceeding further, it will be convenient to consider how the labour of finding Compound Interest may be lessened.

Suppose we have some decimal, such as 5·27463, and that we are asked to write it "correct to three places." This means that we are to write down a number of only three decimal places which shall be as near as possible to the actual value 5·27463. The result is 5·275. For the given decimal is 5·2746... and 46 is nearer to 50 than to 40, so that 5·275 is nearer the true value than is 5·274.

Similarly, the value correct to two places is 5·27.

Again, our smallest coin is the farthing. Hence it is unnecessary, in commerce, to express any sum of money more accurately than "to the nearest farthing"—*i.e.*, we take a value which differs from the true value by no more than half a farthing. Now, 1 farthing = £$\tfrac{1}{960}$ = £·001041... which is very nearly equal to £·001. Thus, if we have a sum of money expressed as a decimal of a £, correct to three places, it will be correct to the nearest farthing. Therefore, in working Compound Interest, if we reject figures beyond the fifth decimal place we shall still obtain the value correct to three places—*i.e.*, to the nearest farthing.

Example. Find the amount at Compound Interest of £38 2s. 6d. in 3 years at 2½ per cent.

$$\begin{array}{r r l}
 & £38 \ \ 2\text{s.} \ \ 6\text{d.} & \\
= & £38{\cdot}125 & = \text{1st year's Principal.} \\
 & 2{\cdot}5 & \\
\hline
 & {\cdot}76250 & \\
 & {\cdot}19060 & \\
\hline
 & {\cdot}95310 & = \text{1st year's Interest.} \\
 & 38{\cdot}125 & \\
\hline
 & 39{\cdot}07810 & = \text{2nd year's Principal.} \\
\end{array}$$

39·07810 = 2nd year's Principal.
2·5
·78156
·19535
·97691 = 2nd year's Interest.
39·07810
40·05501 = 3rd year's Principal.
2·5
·80110
·20025
1·00135 = 3rd year's Interest.
40·05501
£41·05636 = Amount.
20
1·12720s.
12
1·52640d.
4
2·10560 far.
£41 1s. 1½d. *Ans.*

Explanation. Multiply by 2 and move the digits two places to the right, as in Art. **124**. Next, in multiplying by ·5, the first figure of £38·125 which gives a digit in the *fifth* place is the 2. Hence we begin multiplying at the 2, exactly as if the multiplicand only consisted of 38·12. Similarly, in finding the second year's interest, the first digit of 39·07810 which, when multiplied by 2, gives a digit in the fifth place is the 8; and when multiplying by ·5 the first digit required is the 7. Proceeding in this way, we obtain £41·05636, of which not more than the 41·056 will be correct, but this, as we have seen, gives a result correct to a farthing. If we work out the above example in full, we find that the Amount is £41·056455078125. This, when reduced to £ s. d., gives £41 1s. 1½d. + ·196875 farthings; *i.e.*, £41 1s. 1½d., which agrees with the first result. Evidently then, it is a mere waste of labour to work the example in full.

126. In some cases we are told that the interest is payable half-yearly, or quarterly. We proceed in the same way as before, except that we find the interest for a *half* year (or quarter year), and add the principal, to obtain the principal for the second half year (or quarter year), and so on, until we reach the end of the required time.

127. As in Simple Interest, if we are given the Amount (or the Interest), the Rate per Cent., and the Time, we can find the Principal.

First, find the Amount (or the Interest) of £1 for the given time at the given rate. Then we have the proportion:

Amount (or Interest) of £1 : Given Amount (or Interest) :: £1 : Required Principal.

Thus, the principal is found by dividing the given amount (or interest) by the amount (or interest) of £1.

128. Present Worth and Discount. Suppose a man has borrowed £100 at 4 per cent., payable after one year. His debt at the end of the year will be £104. Suppose, also, that he finds himself in a position to discharge the debt at the end of six months, instead of letting it go on for the full year. Clearly, instead of paying £104, he should only pay such a sum as, put out to interest at 4 per cent., will amount to £104 in the remaining six months. By the method of Art. **122**, **Ex. 3**, such a sum is found to be £101$\frac{49}{51}$, or £101 19s. 3d., nearly.

This £101 19s. 3d. is called the *Present Worth* of the £104 due in six months at 4 per cent. The difference between the present worth, £101 19s. 3d., and the amount which would be due in the six months, £104, is called the *True Discount.*

Thus, the problem of finding the Present Worth is exactly the same as that in Art. **122**, **Ex. 3**, when the interest is simple; and is the same as Art. **127** if the interest is compound.

Example **1**. Find the Present Worth, and True Discount, on £40 8s. due in 73 days at 5 per cent.

Interest on £100 for 73 days at 5 per cent. = $\frac{1}{5} \times 5$ = £1.

∴ Present worth of £101 = £100.

Hence £101 : £40 8s. :: £100 : Reqd. P. W.

$$\left.\begin{array}{l} \therefore \text{ Reqd. Present Worth} = £\frac{100 \times 40\frac{2}{5}}{101} = £40 \\ \therefore \text{ True Discount} = £40\ 8s. - £40 = 8s. \end{array}\right\} \textit{Ans.}$$

Example **2**. Find the Present Worth of £1458 14s. 9d. due in 2 years at 3 per cent. Compound Interest.

£1.
·03
1·03 = Amount in 1 year.
·0309
1·0609 = Amount in 2 years.

∴ Present Worth of £1·0609 = £1.

∴ Present Worth of £1458 14s. 9d.

£1458·7375
£1·0609
1·0609)14587375(£1375 *Ans.*
39783
79567
53045

Explanation. Find the amount at 3 per cent. compound interest of £1 for 2 years, *viz.*, £1·0609. Reduce 14s. 9d. to the decimal of £1. Then, since £1 is the Present Worth of £1·0609, the required Present Worth is the quotient of 1458·7375 by 1·0609.

COMMERCIAL OR BANKER'S DISCOUNT. BILLS OF EXCHANGE

129. In commercial transactions, an agreement to pay a sum of money at some stated future date is made by a *Bill of Exchange*, or by a *Promissory Note.*

Suppose a merchant, James Brown, receives an order for goods to the value of £200, from another merchant, John Smith. Instead of paying cash, Smith authorises Brown to draw a Bill, to be paid by Smith after a certain period, usually three months. Brown accordingly writes out the Bill of Exchange, as follows:

Birmingham,
13th November, 1905.
£200.
Three months after date, pay myself, or order, the sum of two hundred pounds, value received.
James Brown.
To
Mr. John Smith,
Merchant,
Leeds.

The document must bear a stamp, the amount of which varies with the amount of the bill. In this case it would be 2s.

The bill is forwarded to Mr. Smith, who "accepts" it—*i.e.*, acknowledges the debt, by writing "Accepted," followed by his signature, across the face of the bill, and returns it to Mr. Brown. The bill is nominally due in three months after November 13th, but the law allows three extra days, called *Days of Grace*; so that it legally falls due, or "matures," on February 16th.

Brown may keep the bill till February 16th and then "present" it for payment, to Smith, or Smith's banker, who will pay the £200.

If, however, Brown is in want of ready money before February 16th, he may sell the bill to a third person, either a banker or a *Bill-broker*, for cash. The broker is then said to have *discounted* the bill. Since the broker has still to wait a certain time before Smith pays the bill, he will not pay Brown £200 for it. Suppose Brown gets the bill discounted on December 5th "at 5 per cent." Then, the number of days before the bill falls due is 26 + 31 + 16 = 73 days. The broker, therefore, calculates the interest on £200 for 73 days at 5 per cent., and deducts that amount (£2) from the *Face Value* (£200) of the bill. He thus pays Brown £198 for the bill.

The amount which the broker deducts from the face value is called *Commercial*, or *Banker's, Discount*. We see, then, that the problem of finding the Banker's Discount is the same as that of finding the Simple Interest on the face value, for a given time, at a given rate (Art. 121).

130. The ordinary form of Promissory Note is as follows:

Leeds,
13th November, 1905.
Three months after date I promise to pay to Mr. James Brown, or order, the sum of £200, value received.
John Smith.

It should be noticed that in the case of a Bill of Exchange the document is written by the creditor, while a promissory note is written by the debtor.

131. Since,

Amount (*i.e.*, Face Value) = Present Worth + True Discount, it follows that

Interest on Face Value = Interest on Present Worth + Interest on True Discount; that is,

Banker's Discount = True Discount + Interest on True Discount.

The difference between the Banker's Discount and the True Discount is, therefore, the interest on the True Discount.

Example. The difference between the Banker's and the True Discount on a certain bill due in 2 years at 5 per cent. simple interest is £1 13s. Find the Amount of the bill.

We know that £1 13s. is the simple interest on the True Discount for 2 years at 5 per cent.

Therefore, by the method of Art. 122, Ex. 3, we can find the true discount. For £10 is the interest on £100 for 2 years at 5 per cent. Hence,

£10 : £1 13s. :: £100 : True Discount.

$$\therefore \text{ True discount} = £\frac{100 \times 33}{200} = £16 \text{ 10s.}$$

The Banker's Discount is, therefore, £16 10s. + £1 13s. = £18 3s., and we have now only to find on what principal the interest for 2 years at 5 per cent. amounts to £18 3s.

∴ £10 : £18 3s. :: £100 : Required Bill.

$$\therefore \text{ Amount of Bill} = £\frac{100 \times 363}{200} = \underline{\underline{£181 \text{ 10s. } \textit{Ans.}}}$$

EXAMPLES 16

1. Find, to the nearest penny, the Simple Interest on £2523 11s. 6d. for 5 years at 3½ per cent.

2. At what rate per cent. Simple Interest, will £875 amount to £980 in 3 years?

3. The simple interest on a certain sum for 8 years at 4½ per cent. is £183 3s. Find the Sum.

4. In what time will money double itself at 4 per cent. Simple Interest?

5. Find, to the nearest penny, the Amount of £1420 in 3 years at 6 per cent. Compound Interest.

6. Find, to the nearest penny, the Compound Interest on £58 4s. 7d. for 2 years at 4 per cent., the interest being payable half-yearly.

7. Find the Present Worth of £231 1s. 10½d. due in 2½ years at 3½ per cent. simple interest.

8. Find the True Discount on £1447 0s. 7½d. due in 3 years at 5 per cent. Compound Interest.

9. A bill due in 3 years is discounted at 4 per cent. The difference between the True Discount and the Commercial Discount is 10 guineas. Find the Amount of the bill.

10. A bill of £400 drawn on December 4th at 8 months is discounted by a banker on March 14th, the rate of discount being 5 per cent. How much will the holder of the bill receive?

Answers to Arithmetic

EXAMPLES 14

1. The second man's stride is 32 in. Since his stride is longer than that of the first man, he will take fewer steps in going the same distance. Hence, 32 : 30 :: 3120 steps : Ans.

$$\therefore \text{ Reqd. number of steps} = \frac{3120 \times 30}{32} = \underline{\underline{2925 \textit{ Ans.}}}$$

2. When the reinforcement arrives there are provisions for 137 − 50 = 87 days. The number of men is now 5000 + 800 = 5800. Hence, 5800 : 5000 :: 87 days : Required time.

$\therefore$ Required time $= \dfrac{87 \times 5000}{5800} = \underline{75 \text{ days } \textit{Ans.}}$

3. After 36 days there are $48 - 36 = 12$ days left, in which time the same amount of work has to be done as was done by 20 men in 36 days. The number of men required to do this is found from the proportion 12 : 36 :: 20 men : Required Number. Whence, Required Number of men = 60. The contractor must, therefore, engage $60 - 20 =$ 40 extra men *Ans.*

4. Candles at 8 to the lb. will burn a shorter time than those at 6 to the lb. Hence 8 : 6 :: 6 hours : Ans. Which gives Required Time $= 4\frac{1}{2}$ hours *Ans.*

5. $\frac{2}{5}$ of the women are unmarried, *i.e.*, $24 = \frac{2}{5}$ of the women. $\therefore$ Total number of women $= \frac{5}{2}$ of $24 = 60$. Now, number of men : number of women :: 3 : 4. Hence, number of men $= \frac{3}{4}$ of $60 = 45$. But 5 men in every 9 are married. $\therefore$ Number of married men $= \frac{5}{9}$ of $45 = 25$ *Ans.*

6. At first $\frac{3}{8}$ of the cask is water. At the finish $\frac{3}{8}$ of the cask is wine. Therefore, when 16 gallons of the mixture was taken out, it left as much wine as there was water to begin with. But 16 gallons of the mixture contains $\frac{5}{8}$ of 16 gallons = 10 gallons of wine. Hence. there were 10 gallons more wine than water to begin with. Now 8 gallons of mixture contains 5 wine and 3 water, *i.e.*, there are 2 gallons more wine than water in every 8 gallons of mixture. Therefore, there are 10 gallons more wine than water in $5 \times 8 = 40$ gallons of mixture. The cask, therefore, held 40 gallons *Ans.*

7. Statement is

$$\left.\begin{array}{r}5 : 72 \\ \pounds 2\ 5\text{s.} : 2\text{s. } 6\text{d.}\end{array}\right\} :: 15 \text{ miles : Ans.}$$

Whence, *Ans.* = 12 miles.

8. 4 men do as much as 8 women. $\therefore$ 1 man = 2 women. Hence, 2 men and 3 women = 7 women. We then have the statement

$$\left.\begin{array}{ll}7 \text{ women} & : 8 \text{ women} \\ 5 \text{ ac.} & : 8 \text{ ac.} \\ 12 \text{ hr.} & : 10 \text{ hr.}\end{array}\right\} :: 3\tfrac{1}{2} \text{ days : Ans.}$$

Whence, *Ans.* $= 5\frac{1}{3}$ days.

9. Calling the boys A, B, C, D, we have

A's 4 pages = B's 5 pages
B's 6 ,, = C's 7 ,,
C's 3 ,, = D's 2 ,,
Reqd. D's = A's 18 ,,

Hence,

$$\textit{Ans.} = \frac{5 \times 7 \times 2 \times 18}{4 \times 6 \times 3} = \underline{17\tfrac{1}{2} \text{ pages.}}$$

10. As in Art. **112**, Ex. **2**, we have

A's 100 = B's 99
B's 120 = C's $118\frac{3}{4}$
Reqd. C's = A's 1760

Therefore, while A goes 1 mile, C goes

$$\frac{99 \times 118\frac{3}{4} \times 1760}{100 \times 120} \text{ yd.} = 1724\tfrac{1}{4} \text{ yd.}$$

Therefore, A beats C by $1760 - 1724\frac{1}{4} = 35\frac{3}{4}$ yd. *Ans.*

11. The *values* are as 2 : 3 : 4, which is the same thing as £2 : £3 : £4. Now £2 = 16 half-crowns, £3 = 30 florins, £4 = 80 shillings. Therefore, the *numbers* of the coins are as 16 : 30 : 80. We have, then, to divide 126 coins proportionately to 16, 30, 80. But $16 + 30 + 80 = 126$. Hence, the heap contains 80 shillings *Ans.*

12. The statement is

$$\left.\begin{array}{rll}55 & \text{yd.} & : 120 \text{ yd.} \\ 20 & \text{ft.} & : \ \ 25 \text{ ft.} \\ 5 & \text{ft.} & : \ \ \ 4 \text{ ft.} \\ 12 & \text{hr.} & : \ \ 11 \text{ hr.} \\ 5 & \text{days} & : \ \ \ 4 \text{ days}\end{array}\right\} :: 100 \text{ men : Ans.}$$

Whence, 160 men *Ans.*

EXAMPLES 15

1. To lose 5 per cent, he must sell for 95 per cent. of cost. To gain 7 per cent., he must sell for 107 per cent. of cost. $\therefore$ 95 : 107 :: £247 : Required Price. Hence, he must sell for $247 \times 107 \div 95 =$ £278 4s. *Ans.*

2. He buys *equal* numbers at the two rates, and sells 5 for 3d. Take, then, the L.C.M. of 2, 3, and 5, *i.e.*, 30. Now 30 at 2 a 1d. cost 15d., and 30 at 3 for 2d. cost 20d. The total cost is 35d. He sells the whole 60 at 5 for 3d., *i.e.*, for 36d. He thus gains 1d. on an outlay of 35d. His gain % is $\frac{1}{35}$ of $100 = 2\frac{6}{7}$ *Ans.*

3. 9s. 7d. – 9s. 2d., *i.e.*, 5d., is 4 per cent. of the cost, or $\frac{1}{25}$ of the cost. $\therefore$ Cost $= 25 \times 5$d. = 125d. Hence, by selling at 9s. 7d., he loses 10d. His loss per cent. is $\frac{10}{125}$ of 100 = 8 per cent. And, therefore, by selling at 9s. 2d. he loses $8 + 4 = 12$ per cent.

4. 750 eggs at 15 a shilling cost $750 \div 15 = 50$s. He loses 2 per cent. of this, *i.e.*, he loses 1s. But the number of eggs he lost was 13. Hence, he sold 13 eggs for 1s.

5. 24 lb. of tea at 1s. 10d. cost £2 4s.; 8 lb. at 2s. 10d. cost £1 2s. 8d. The total cost of 32 lb. of tea is, therefore, £3 6s. 8d. To gain 10 per cent. he must sell the 32 lb. for $\frac{110}{100}$ of £3 6s. 8d. Hence, the selling price per lb.

$$= \frac{11 \times \pounds 3\ 6\text{s. } 8\text{d.}}{10 \times 32} = \underline{2\text{s. } 3\tfrac{1}{2}\text{d. } \textit{Ans.}}$$

6. As in Art. **119**, Ex. **5**, if he buys 5 per cent. cheaper and sells to gain 4 per cent. he sells for $\frac{95}{100} \times \frac{104}{100}$ of actual cost $= \frac{247}{250}$ of actual cost. But he really sells to gain 10 per cent., *i.e.*, for $\frac{11}{10}$ of cost. Therefore, £168 is $(\frac{11}{10} - \frac{247}{250})$ of cost. Whence, cost = £1500, so that to gain 10 per cent. he must sell for £1650 *Ans.*

7. Marked price = 20 per cent. above cost $= \frac{6}{5}$ of cost. Selling price $= \dfrac{92\frac{1}{2}}{100}$ of marked price $= \frac{37}{40}$ of $\frac{6}{5}$ of cost $= \frac{111}{100}$ of cost. $\therefore$ He gains 11 per cent.

8. He sells one house for $\frac{11}{10}$ of cost. $\therefore$ Cost $= \frac{10}{11}$ of £990 = £900. He sells the other for $\frac{9}{10}$ of cost. $\therefore$ Cost $= \frac{10}{9}$ of £990 = £1100. $\therefore$ He bought the two for £2000, and sold them for £1980. $\therefore$ He loses £20.

Continued

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OUTLINES OF EDUCATIONAL TOURS ABROAD

A Brief Guide to all Places of Interest in the Leading Towns of Spain and Portugal. Where to Go and What to See

By J. A. HAMMERTON and WILLIAM DURBAN, B.A.

SPAIN

What traveller would willingly miss the land of the hidalgo, of the Cid, of Don Quixote, of the noblest age of the Mauresque civilisation, of fairy-like architecture, of pristine chivalry, of glorious sunshine, and of semi-tropical fruitfulness? Fallen from its mediæval greatness though it is, Spain fully retains the gorgeous colouring of its unique romance, and its multitudinous and varied attractions of scenery, architecture, archæology, and popular custom offer endless interest to the visitor. Spain has been comparatively neglected by English tourists, but during the last few years the tide of patronage has set steadily in this direction. It is easy to acquire a sufficient knowledge of the beautiful and sonorous Castilian language for the purpose of a visit, and the country lies within easy access of our shores, whether overland through France or by direct sea passage. The people are among the most courteous on earth, and are abundantly solicitous of the comfort of those who wish to make any sojourn among them.

The traveller in the ordinary way reaches Biarritz by way of Paris, and from Biarritz proceeds over the Pyrenees to Burgos.

A Week in Spain. So short a stay will be fully occupied by visiting Madrid, Toledo, and Cadiz, these being the best points to select for so brief a period. The tourist who cannot afford a longer holiday will gain a gratifying glimpse of the country and the people, and will learn something of the national spirit.

A Fortnight in Spain. Even this is all too short, but it will be filled with enjoyment, and will afford opportunities of visiting a number of the most famous cities.

FIRST DAY. Few places are more interesting than BURGOS, a wonderfully beautiful old-time city, the birthplace of Spain's national champion, the Cid. The magnificent *Cathedral*, in certain respects unrivalled in the world. Its fourteen chapels. Each of these is in reality a fine church. The crucero, or lantern, is the gem of the whole structure. Philip II. said it was built by angels rather than men. The transept, full of marvellously delicate sculpture. The beautiful High Altar. The splendid choir, in two tiers, with walnut stalls. The *Town Hall*, in which is the body of the Cid. The *Castle*, where the Cid was married. Carriage drive to the famous Monasteries of *Las Huelgas* and *Miraflores*.

SECOND DAY. That marvellous edifice, 25 miles N.W. of Madrid, *El Escorial*, is reckoned by Spaniards as the eighth wonder of the world. It has been aptly described as "a mountain of granite shaped into a palace, a church, a convent, and a mausoleum." It is the leviathan of architecture. It is the mammoth tomb of the kings and queens of Spain, is constructed of solid granite, was erected by Philip in commemoration of the Battle of St. Quentin, and took twenty years in building. The *Panteon*, or Royal family tomb. All of marble and jasper. Sixty bodies of Royalties lie here. The *Convent*. Many pictures and statues. The rich and beautiful *Library*. The splendid *Palace*, with its magnificent towers. The grand *Church*, with sumptuous chapels and altars, and the richest reliquary in Spain.

THIRD DAY. The most elevated of all European capitals is MADRID. The first day to be spent in a survey of the many beautiful, spacious squares, all finely adorned with trees, and of the wide streets and interesting shops. It is a city of flowers. The fruit markets are marvellous at the right season. The *Plaza Mayor* and *Plaza del Oriente* are centres of the busiest and most fascinating life.

FOURTH DAY. The second day at Madrid. The *Museo*. Here is that picture gallery which is the envy of every other city in Europe. A collection of splendid gems of pictorial art. No fewer than forty-six Murillos, including the world-famed "Conception"; sixty-four Velasquezes, including the great equestrian portrait of Philip IV.; ten Raphaels, including the "Holy Family," called "La Perla," because Philip IV., on beholding it, exclaimed, "This is the pearl of my pictures"; with numerous works of Titian, Ribera, Teniers, Van Dyck, Tintoretto, Veronese, Claude, etc., etc. The *Royal Armoury* contains an unrivalled collection of weapons of all ages, together with the armed effigies of kings, emperors, and generals in suits of armour the most resplendent ever manufactured.

FIFTH DAY. A third day would be spent at Madrid. The *Royal Palace*, one of the grandest in Europe. The Grand Patio, or Square, and the thirty saloons, magnificently furnished, on the first floor. The beautiful garden. The *Church of San Francisco*, with historic tombs and curious pictures. The *Church of Atocha*, with venerated miraculous images.

SIXTH DAY. TOLEDO is grandly situated on a high rock by the Tagus, which almost circumvents the city. The whole town is a museum of the majestic and romantic past, specially rich in Mauresque edifices. The wonderful *Cathedral*, the finest in Spain next to that of Seville. The famous façade, with relievo of the Last Supper, containing sixty full-sized statues. The portals are also celebrated for their exquisite ornamentation in stone. The noble tower, 329 ft. high. The five naves, the 750 stained windows, the Royal tombs, the chapels round the church, and the lovely cloisters, all make a memorable spectacle. The beautiful Gothic pile known as the *Church of San Juan de los Reyes*. The famous *Alcazar of Charles V.*, an immense ruin of golden red colour.

SEVENTH DAY. A city of which any nation might be proud is SEVILLE, the delight of every visitor, beautifully situated on the banks of the Guadalquivir, full of wonderful architectural relics of the Moorish period. The famous *Cathedral*, one of the most sublime ecclesiastical creations in the world. Its Giralda Tower is a gem of Saracenic construction, of loveliest rose tint. The stained windows, ninety-three in number. The Court of Oranges. The nine doors of entrance to the Cathedral are sumptuous portals. The pavement of black and white marble cost £30,000. Seven naves of imposing perspective and immense height. The enchanting view from the summit of the Giralda.

Eighth Day. Two days are necessary to give any idea of Seville. The glorious *Alcazar*, or House of Cæsar, an ancient Moorish palace. Matchless internal decoration in arabesques. This is, next to the Alhambra at Granada, the most precious and perfect Moorish monument in Spain. The loveliest portion is the Patio, with marble pavement, fountain, and trefoiled arcades, which are considered marvels of grace and lightness. The palace called the *Casa de Pilatus*, belonging to the Duke of Medina Celi, built as an imitation of the house of Pontius Pilate at Jerusalem. It contains a noble Patio. The *Golden Tower* on the bank of the river ; formerly a fortress. Delightful hours are to be spent in surveying the streets and squares of this fascinating city. The famous Tobacco Factory, with thousands of girls at work, should be seen.

Ninth Day. Reach Cadiz. The Biblical Tarshish. One of the world's most venerable cities, yet a delightful modern town full of fascination for the visitor. On a peninsula, joined only by a narrow causeway to the mainland. A place of brilliant colour, with shining white walls, long rows of elegant houses, glass and gilt balconied miradores. The granite ramparts and spacious terraces afford delightful promenades. *La Vieja*, or Old Cathedral, with thirteen chapels. The *Cathedral of Santa Cruz*, or New Cathedral, imposing in style, and richly ornamented with precious marbles and jasper. *Los Capuchinos*, an old convent, with renowned picture gallery containing gems of art, including Murillo's last work, the famous "Marriage of St. Catherine." The shops of Cadiz are specially attractive, for the city is famous for fans, ladies' shoes, gloves, and guitars.

Tenth Day. Gibraltar. The *Lower Fortifications*, the *Rock Galleries*, the *Signal Tower*, the *Cave of St. Michael*, and the *Alameda*, or fashionable and charming promenade, called the "Pride of Gibraltar," laid out in English style, abounding in geraniums and bowers, and commanding exquisite views of the Straits and the African coast. The town has quaint and curious winding, narrow streets.

Eleventh Day. We come now to Granada. The wonder-city of Spain. A place of fountains and rippling streams, situated on one of the loveliest plains in the world. It stands on four hills, divided somewhat like a pomegranate, and rises to the height of 2,245 ft. above the sea-level. The snow-clad mountains of the Sierra Nevada range adorn the prospect. The city extends in an amphitheatre round the river bank, and is crowned by the incomparable *Alhambra*, the supreme gem of Moorish architecture. The gardens and woods round this building are exquisitely beautiful, and are the haunt of countless nightingales. The Hall of Ambassadors, the Court of Lions, the Lion Fountain, and the various other halls, courts, corridors, apartments, and fountains make up a bewildering scene of indescribable enchantment. The noble *Cathedral*, with five naves, dome of white and gold inside, the fine marble pavement, and lovely chapels. *La Cartuja*, a famous monastery and church, just outside the town, with magnificent frescoes.

Twelfth Day. Cordova. Exquisitely situated on the Guadalquivir. Famous for its superb *Cathedral*, formerly a grandiose mosque. The most perfect specimen extant, or ever erected, of Moorish architecture. The beautiful Patio, called the Court of Oranges. The Hall of Thousand Pillars, forming nineteen spacious naves. The unrivalled mosaics.

Thirteenth Day. Barcelona. The fine *Cathedral*, the *Rambla Promenade*, and the *Bull-ring*.

Fourteenth Day. Back to Madrid.

Travel and Food. Railway travelling in Spain is now perfectly comfortable, and hotel accommodation in the cities is greatly improved. The food is excellent. Bull beef is the staple meat. Fruit is abundant and unsurpassed. Grapes, oranges, melons are of the most magnificent varieties. Eggs fried in oil or mashed with tomatoes are everywhere offered. Water is scarce. Beggars are numerous and insolent. The amusements are the universal guitar-playing, the wonderful dancing of both sexes, and the brutal bull-fights.

If the tourist wishes to spend three weeks or a month in Spain he may make extensions to Cartagena, Pampeluna, Zaragossa, Boadilla, Malaga, La Roda, Utrere, Irun, Xeres, Algecir, etc.

Expense. The cost of a circular trip such as we have described above, occupying a fortnight, should not be more for steamer and railway tickets than £25 first class, or £20 second class. About 12s. a day should be reckoned for hotel expenses and extras.

Treatises on travel in Spain are very numerous, and afford delightful and useful reading for the intending tourist. We may commend Mrs. Ramsay's "Summer in Spain," Pemberton's "Winter Tour," Rose's "Among Spanish People," Workman's "Awheel in Iberia," Jacacci's "On the Trail of Don Quixote," Lawson's "Spain of To-day," Hare's "Wanderings," Lomas's "Sketches," Hay's "Castilian Days," Elliott's "Idle Woman in Spain," Robert's "Autumn Tour in Spain," Thornbury's "Life in Spain," Gadow's "In Northern Spain," Wood's "Romance of Spain," McClintock's "Holidays in Spain," St. Barbe's "In Modern Spain," Gallenga's "Iberian Remains," Luffman's "Vagabond in Spain," Main's "Cities and Sights of Spain," Crocket's "An Adventurer in Spain," and Bart Kennedy's "A Tramp in Spain."

PORTUGAL

It may almost be reckoned that Portugal as a holiday region for British tourists has been "discovered" by King Edward through his visits in recent years. Comparatively few in this country were formerly aware how lovely is the western section of the Iberian Peninsula. It is a land of fruit and flowers all through the year. Here the orange and the lemon, the almond and the walnut, the olive and the loquat, the prune and the cherry, the peach and the grape reach their highest perfection. The humblest cottages are embowered in roses, and flowers that are nursed as exotics in northern climes are in Portugal as plentiful as weeds. This delightful little country is the California of Europe. The celebrated harbour of Lisbon is acknowledged by Americans to surpass the Golden Gate of San Francisco. The people are a self-respecting, interesting race, proud of their home and contented with it.

Portugal is so easily accessible that it is almost as convenient to visit as France, Holland, or Belgium. Of course, the direct route is by sea to Lisbon, which is the natural door into the country.

A Week in Portugal. This is sufficient for a survey of Lisbon, Cintra, Belem, and Oporto. The majority of visitors confine their attention to these points, and either pass on to Madrid or proceed round the Peninsula to the Mediterranean.

A Fortnight in Portugal. Two weeks allow opportunity for a glorious round in one of the world's historic districts, full of the most romantic associations, and of the utmost beauty.

First Day. Lisbon is a marvellous capital for a tiny nation, and is built on seven hills, in terraces rising one above the other. The Tagus is here broad and majestic. The city is said to have been founded by Ulysses, and originally called Ulyssipi. Grand squares, with fine trees, lovely flowers, and marble fountains. The most curious of these open spaces is the *Prazo dom Pedro*, nicknamed "Rolling Wave Square" from the fantastic arrangement of its tesselated pavement. The beautiful Garden of *St. Pedro di Alcantara.*

Second Day. The *Cathedral* at Lisbon is an ancient and massive Gothic edifice, which withstood the great earthquake, the Chapel of St. Vincent being one of Lisbon's chief ecclesiastical ornaments. The *Church of St. Roque*, with the famous Chapel of St. John the Baptist. The decorations of this chapel are wonderfully elaborate, being encrusted with mosaics of Italian masters, lapis lazuli, and costly marbles ornamented with gold and amethysts. The *Estrella Church*, a beautiful miniature of St. Peter's at Rome. The prospect from its dome is magnificent.

Third Day. Four days may be devoted to Lisbon. On the third visit the *Gallery of Fine Arts*, the *Museum*, the *Pant eon*, the *Artillery Museum*—all these institutions contain fine old collections of national relics from the days of Portuguese greatness. The *Aqueduct*, a splendid engineering construction bringing water from springs nine miles distant.

Fourth Day. Still at Lisbon, the fourth day would be given to visiting Belem, a famous and beautiful suburb of Lisbon, named after the wonderful *Hieronymite Church* in its midst, founded by Vasco di Gama as a thank-offering after his safe return from the East Indies. The cloisters are of the utmost beauty. Here are the tombs of Di Gama, Camoens, and Catherine of Braganza. The *Royal Palaces* of Lisbon—the Necessidades and the Ajuda. The splendid Gothic monasteries of *Batalha* and *Alcobaca*, in the suburbs of the capital.

Fifth Day. Visit Cintra. Byron termed this famous *Castle* "a blessed Eden," and Southey described it as "the most blessed spot in the habitable world." Situated on a grand rock, it was once the Alhambra of the Moorish kings. *Chapel*, with lovely transparent alabaster work. The *Castle of Montserrat*, on another peak near by, with exquisite gardens.

Sixth Day. Across the wide Tagus is Setubal, an important port. Grand harbour; fine quays: five massive forts. The environs are crowded with beautiful groves of orange, lemon, and olive trees. The place is full of natural charm.

Seventh Day. Evora. This city is generally considered the most beautifully situated in the whole country, and it is one of the most interesting. The ruins of the walls and forts are astonishing. In the immense *Gothic Cathedral* are fine pictures by Gran Vasco; also a famous *Library*.

Eighth Day. Faro. A beautiful and wealthy episcopal city, famous for historic associations and for its splendid old *Moorish walls*. In the noble bay are three charming islands.. Lovely environs, thickly planted with orange and fig trees and splendid cork oaks. Great fisheries.

Ninth Day. Spend this at Beja. Wonderful *fortifications*, with forty towers; massive old *Castle*; fine *Cathedral*. Extensive leather and earthenware factories. A characteristic Portuguese town.

Tenth Day. Coimbra, on the Mondego, is by many reckoned the most interesting city in the land. The town stands on a conical hill in a superb situation. Its aspect from every side is exceedingly beautiful, and the whole city is picturesque and attractive. The neighbourhood abounds in charming scenery, and is fascinating for excursionists. At least two days should be spent here.

Eleventh Day. During the second day in this old Gothic city further details are to be studied. The fine *Aqueduct* of twenty-one arches. Portugal's only *University* is here. Attached to it is the lovely *Botanic Garden*. The noble *Cathedral*. The handsome churches of *Santa Clara* and *Santa Cruz*.

Twelfth Day. Oporto. Portugal's great commercial emporium. Its buildings, erected in tier after tier, present a magnificent picture. The remnants of the ancient walls. The fine business streets are intensely interesting. The *Rua Nova dos Inglezes* is a splendid thoroughfare. The *Rua Nova de S. Joao*, with lofty houses and gaily painted and gilt balconies.

Thirteenth Day. Second day in Oporto. Walk in the various grand squares, for which Oporto is famous. The grandest is the *Praca de S. Ovidu*, on a hill, giving a magnificent sea view. The *English Factory House*, of white granite, with beautiful façade. The *Convent da Serra*, perched on a high rock. The fine old *Cathedral*. The *Torre de Clerigos*, the highest tower in the country.

Fourteenth Day. Back to Lisbon.

Travel and Food. Travel in Portugal is constantly interesting. The courteous, frugal, and industrious inhabitants have a fascination of their own. The atmosphere, laden with Atlantic ozone. is uniformly bracing. The enchanting climate, the radiant sunshine, the brilliant moonlight nights, and the semi-tropical vegetation impress the visitor with a sense of indefinable charm. The bullfights, so repulsive in Spain, are mild and harmless here. It is a land of domestic comfort. Every description of food is exceedingly cheap, and rent is lower, perhaps, than anywhere else in Europe. Europe has no finer market than that of Lisbon. The meat is much better than in Spain, and the fish is unrivalled. Nowhere on the Continent can fruit and vegetables be obtained in greater abundance or of superior quality. Thus Portugal is peculiarly enjoyable as a pleasure resort.

Fares. The sea passage to Oporto or Lisbon from Liverpool costs £6 first class single. The boats of the Booth Company run weekly. There are no second or third class tickets, though these may be obtained from Havre, and there is no reduction for return ticket.

Books. Those who purpose visiting Portugal should previously read some of the following works: Lady Jackson's "Fair Lusitania," Leck's "Iberian Sketches," Smith's "Spring Tour," Latouche's "Travels in Portugal," Shore's "Three Pleasant Springs in Portugal." and O. Crawfurd's "Round the Calendar in Portugal."

Continued

Continued from

THE RISE OF THE ROMAN EMPIRE

The Building of Rome. Its Early Rulers. Election of Consuls. The Patricians and the Plebeians. Rome under the Oligarchy

By JUSTIN McCARTHY

THE history of Rome belongs to a much later period of the world's development than that of Egypt or of Greece. The whole Italian peninsula appears to have attracted the attention of colonists from foreign States at a much later date than many other parts of Europe, which would seem to us after a glance at the map to be much more difficult of access than the Italian regions. But Italy, barricaded on all her northern frontier by lofty mountains, showed also too long a stretch of harbourless coast on either side to tempt the enterprise of the small and imperfectly constructed vessels which such early traders as the Phœnicians could send out in those remote ages.

Early History. The Roman States did not, even at a time when Rome was approaching the zenith of her greatness, spread over the whole of the Italian peninsula. Of the tribes which originally occupied the greater part of Italy, the Latins, the Sabines, and the Etruscans were the most numerous, the most civilised, and the best adapted for development and progress. The Latins and the Sabines appear to have been alike populations of native growth, although during the course of their history we shall find that they proved as hostile to each other as any two foreign races brought together by invasion and thus settled in the same country. The Etruscans were a people of foreign descent, and continued to be in almost every sense foreigners while they held their place upon Italian soil. They constituted a powerful State while Rome was yet obscure, and if they could only have become united among themselves, they might have conquered the whole of that part of Italy in which Rome was to grow up.

They were a highly artistic people, and some of the best monuments which tell of Rome's early growth are described as bearing distinct evidence of Etruscan creation. The Italian language is declared to have been Etruscan at its best. The Etruscans loved the sea, and were at home there alike as commercial traders and as sea-rovers and pirates.

The Growth of a State. The earliest history of Rome is merely legendary or mythological. It is the only history we have, and it may perhaps be taken as representing, apart from its fabulous and impossible additions, the beginning and early growth of Rome into a State. Rome is said to have been founded by Romulus about 750 years before the Christian era. This much, at least, we may accept on the safe assumption that it is about as likely as anything else. Then we come to the legendary and the mythological. Romulus and Remus are described as the sons of Rhea Silvia and of Mars the war god. The mother of the children having been a vestal virgin, consecrated to a life of purity and celibacy, was condemned with her children to be drowned in the River Tiber The cradle in which the brothers were cast into the water was flung ashore by chance, and thrown near to the den of a she-wolf, who treated them as if they had been her own cubs, suckled them, and brought them up. Macaulay, in one of his "Lays of Ancient Rome," makes one of his figures apostrophise the Roman:

> "Thou that art sprung from the war-god's loins,
> And hast tugged at the she-wolf's breast."

The children are said to have been found by a shepherd, who carried them from the den to his own home, where they were brought up by his wife. When they grew up, conscious, no doubt, of their remarkable descent, they set out to found a city on the banks of the Tiber, and this enterprise proved fatal to one of them. Remus, according to some legends, quarrelled with his brother because Romulus insisted that the city should be called Roma, from his own name. Another story tells us that when the first wall of Rome had been built, Remus showed his contempt for the undertaking by leaping over the wall—that wall which was meant to be protection against all invasion—and thus aroused the anger of Romulus to such a degree that he killed Remus on the spot.

Building of Rome. Romulus continued his work as a city founder, and Rome was built —not in a day, but with patience and success; and he was accepted as the first sovereign of the new State. Rome soon became well peopled with men, but there were hardly any women within its walls. This obviously would never do. Here, again, we are given to assume that celestial inspiration came to the aid of Romulus, although it does not seem to have been the kind of inspiration which the ordinary mortal could expect from a celestial source. Romulus made proclamation that a splendid series of games and festivities was to be carried on in Rome, and invited the Latins and the Sabines, his near neighbours, to grace the sports by their presence.

The invited guests thronged to the new city in large numbers, and while the festival was going on the Roman youths, already instructed by their ruler, rushed in on the festal ground and carried off the young women. After long altercations, this extraordinary capture of their women led the Sabines to make war on Rome. A new marvel was then to occur. During a long and desperate battle between the Romans and the Sabines, the captured Sabine women, who seemed to have become meantime completely reconciled to their captors, rushed upon the field of battle, threw themselves between the opposing hosts, and implored their fathers and brothers to enter into terms of peace with their

Roman neighbours. To the modern reader it might seem as if the devotion of the Sabine women to their Roman captors could only increase the hatred of the Sabine fathers, brothers, and lovers for those new favourites of their womenkind. But the Sabine warriors magnanimously yielded to the prayer of the women; the two armies consented to sheath their weapons; the two peoples agreed upon terms of peace, and resolved to form themselves into one united State.

Rulers of Rome. For a time, Romulus and the Sabine king reigned together over the new State, and on the death of the Sabine sovereign, Romulus reigned alone for nearly forty years. According to legend, Romulus was taken from this world to the realms of immortality in a fiery chariot by his father Mars. He afterwards appeared as a spirit to a Roman friend, and bade that friend bear a message to the Roman people, ordering them to pay homage to Romulus as their guardian deity, and to give him the name of Quirinus. There is, indeed, another story, having less of the miraculous, which tells us that Romulus became an insufferable tyrant, and that the Roman senators, finding his rule intolerable, put him to death secretly, cut up his body into small portions, carried the portions home with them under their robes, and buried them in various places, the better to secure the secrecy of the deed. Then, it may have been, that some senator conceived the idea of the god Mars carrying the living Romulus up to heaven in a fiery chariot.

After the death of Romulus the story of Rome's development goes on to tell of six other kings of Rome. Numa Pompilius was the second, and his reign is said to have been one of absolute peace and prosperity, extending over a period of nearly forty years. Numa was followed by Tullus Hostilius, Ancus Martius, Tarquinius Priscus, and Servius Tullius. Servius Tullius, the sixth king, distinguished himself by endeavouring to establish something like an equalised constitution among Roman citizens. We are told that he was in favour of establishing a property qualification for citizenship rather than the qualification of birth and rank, and that by these proposed reforms he aroused the implacable hostility of some of the patrician order, and was assassinated by them, or at their instigation. He was succeeded by Tarquinius Superbus, the haughty and selfish monarch who was destined to be the last of the Roman kings. Tarquinius is described as having some qualities of statesmanship, as well as of conquest, and by wars and political and family alliances he made Rome the chief nation of the Latin races.

Tarquinius Superbus. He abolished many of the rights and privileges which had been conferred by his predecessor upon the Plebeians, for from the beginning of Roman history there had been that division of the people into two classes, the Patricians and the Plebeians. Some events which legend ascribes to the reign of Tarquinius Superbus—"Tarquinius the Proud"—have afforded subjects for poetry and the drama down to modern days. Sextus, the son of Tarquinius, was guilty of a shameful outrage upon Lucretia, the wife of his own cousin. When he had left her in her agony and shame, Lucretia sent for her husband and father, who came with some friends, and to them she told the story, implored them to avenge her wrong, and in their presence stabbed herself to the heart. One of those in that horrified group was Lucius Junius Brutus, a nephew of the reigning sovereign. That sovereign had already, in one of his bursts of suspicion and hatred, put to death the elder brother of Junius Brutus, and Junius, in order not to be regarded as dangerous to the sovereign, assumed the ways and manners of a harmless idiot. For that reason he received and adopted the added name of Brutus, which meant an idiotic personage, Junius being his family name, the name of an influential house among the higher Romans.

Junius now threw off his assumed deportment of idiocy, swore with all the others to avenge Lucretia's wrong, and put himself at the head of those who were determined on vengeance. Brutus summoned the Roman people together, told them the story, and called on them to punish the tyrant. The whole city took up the cause, and pronounced for the deposition of the King, and for his instant banishment from Rome. Tarquinius fled and took refuge in Etruria. Some of the neighbouring kings and States espoused his cause, and marched their armies against Rome. Brutus, in the meantime, had been elected one of the two first Consuls to whom the government of the State, now to be formed into a Republic, was to be committed.

Election of Consuls. These Consuls were to be supreme magistrates, having equal authority, and to be elected annually. The consular office appears and reappears at various times during succeeding ages of Roman history. Tarquinius had the assistance of Lars Porsena, the sovereign of Clusium, who proved a very powerful ally, and whose name has been made familiar to modern readers by many historians, poets, and dramatists. The famous battle of Lake Regillus decided the struggle in favour of the Romans. Tarquinius escaped and died miserably in exile.

A familiar story told of Brutus is that he ordered the execution of his own two sons because they were engaged in an attempt to restore Tarquinius, so absolute and unselfish was his devotion to the interests of his country. Lars Porsena proved so successful in his march against Rome that he was able to occupy a great hill outside the city, and would have entered the city itself by the bridge which connected the hill with Rome, but for the gallant defence made by Horatius Cocles. The story of that brave defence, whether it be a real event or a fabulous creation, has been told and re-told in many languages since the first consular days of Rome. Macaulay tells it over again in his "Lays of Ancient Rome," and reminds us how:

"With weeping and with laughter,
Oft is this story told:
How well Horatius kept the bridge
In the brave days of old."

THE SABINE WOMEN INTERVENING BETWEEN THE ROMANS AND SABINES

Photo Neurdein

Lars Porsena finally made peace with the Romans, and withdrew his forces. But the terms on which peace was made are variously stated. The Roman historians generally endeavour to make out that Porsena had no alternative but to make peace; but the general opinion, both of the ancient and of the modern world, is that Porsena, although he did not persist in striving to occupy the city, held it for a while at his mercy, and only withdrew his troops on condition that the Romans should pay him a yearly tribute as a practical evidence of submission to conquest.

Roman Characteristics. Up to this period the story of Rome has little or nothing in it which is absolutely authentic—little or nothing which can be established by any actual record—while many of its incidents and events are utterly and obviously fabulous. But we can get, even from the Roman story as we have it, a very clear idea of the general character and ways of the people it describes—the people who at one time believed in it. Modern discovery makes it certain that the foundation of a walled city on the Palatine Hill was unquestionably laid in some dim early period, which might well correspond with the creation of the city of Rome. We can learn from that story, fabulous or not, what were the characteristics which the early Romans admired and reverenced in their leaders and their heroes, in their wives and their children, and what were the qualities regarded as evil and dangerous to public and private welfare. We can see that the Romans loved and honoured courage, unselfishness, self-sacrifice, in men and women alike; that they honoured purity in women and filial devotion in children; that they admired literature, art, and knowledge; and, even while far too much given up to aggression and conquest, still regarded as among humanity's highest qualities a sincere desire for peace.

History and Tradition. The reports which reach us, in whatever form, may be taken to represent the general belief of the time, and thus far can be accepted as a contribution to history. We may assume that the general impression left on the mind of succeeding generations by those earlier princes must have represented in some degree their reigns and characters. Therefore, it is at least a reasonable assumption that tradition gives us in that sense a fair idea of the times, the great events, and the reigning sovereigns in Rome's earliest history. It is not probable that tradition represented a man who was a brutal tyrant as a wise, just, and beneficent sovereign, or that some man of high character who strove to make his subjects happy was a Tarquinius Superbus.

There is nothing improbable about the story of those early rulers as it has been handed down to the modern world, and, in absence of all evidence to the contrary, we may accept it as generally trustworthy.

We have already seen that in its earlier days the population of the Roman State was mainly divided between the order of the Patricians and the class of the Plebeians. Such is the earliest condition of most races and nationalities which have been able to form themselves into separate and distinct States. The men who own the land constitute the one order, and the men who work for them on the soil, or for the supplying of their daily wants, constitute the other. Thus, it necessarily came to pass that when the last of the earlier Roman rulers was driven from his throne, reconstitution of society in Rome was left to the two classes, the Patricians and the Plebeians. The Patricians had been mainly instrumental in bringing the monarchy to an end, for the obvious reason that they were better educated, had more time to give to the observation of affairs outside their own ordinary means of living, and were, therefore, better qualified to form a judgment as to the merits of the system by which they were ruled. The Patricians gained most by the abolition of the kingly system, while for the Plebeians things went on afterwards very much as they had done before, and the struggle for life remained practically the same.

Rome under the Oligarchy. All classes in Rome were now probably agreed that the State and its people would be better served by electing magistrates to rule over its affairs during a certain fixed tenure of office, and then to be succeeded by others elected on the same principle. The idea of equality in citizenship had spread so far, even then, that the Plebeians were entitled to give their votes and to declare their views at public meetings. But the Patricians, the men of means and standing, always had influence enough to keep the offices of State among their own order. The Patricians, therefore, gained much, and at once, by the revolution in favour of a republican system, but for the Plebeians it brought for the time little or no appreciable advantage. The new conditions of the State were not by any means those belonging to a Republic in the more recent sense of the word. Rome was ruled by an oligarchy—that is, by a system of government which gave the whole control of affairs into the hands of a few, that few being the Patricians. The same sort of struggle between the Patricians and Plebeians, the landowners and the labourers, the rich and the poor, the privileged and the unprivileged, has been part of the history of almost every country, but it has seldom been seen more distinctly marked out than in the early history of Rome.

The Power of the Consuls. When the Tarquin monarchy had been brought to an end, the Patricians, who then had to frame a new constitution, resolved upon the appointment, by election, of two ruling magistrates to be called Consuls, who were to be elected annually. These Consuls were not required under this new constitution to consult and take joint action on all State questions, but each was allowed to act on his own judgment concerning affairs coming under his immediate jurisdiction. The reason for this power of individual action was probably found in the assumption that sudden difficulties might arise in different parts of the State, that the Consuls might at a critical moment be widely separated, and that it might not be possible to wait for an opportunity of counsel and joint action. It was provided in the constitution that if any serious difficulty of this kind should arise, or if the two Consuls could not agree on the policy to be adopted at some momentous crisis, they might appoint a Dictator, who should have absolute power for six months. The idea of popular representation had gone far enough in those days to secure for the Plebeians a vote in the election of their officers, but they were not allowed to vote for any but members of the Patrician order.

One result of this principle of consular election was that the Consuls became naturally anxious to conciliate the favour and the goodwill of their own class, and were apt to be somewhat indifferent towards the rights of the Plebeians, who were not allowed to choose anyone of their own order as a rival candidate for election. The Patrician class gave to the Army all its officers. The Romans had a Senate, but the Senate was entirely made up from the Patrician class, and naturally gave its main attention to the interests of the Patricians.

The Plebeians Assert Themselves. The Plebeians soon began to appreciate their numerical strength, and were gradually beginning to feel that by union and organisation among themselves they might be able to make some head against the domination of their masters. The Patricians, let them do their worst, could no longer hold their working classes as mere slaves, and they soon realised that they must, for their own sakes, come to terms with the Plebeians.

In the meantime, there were constant wars going on with neighbouring States; with the Etruscans, who got the better of the Romans in some battles, and at one period would seem to have attempted, if they did not actually accomplish, the capture of Rome ; and with some of the neighbouring Latin races, who struggled to regain their complete independence when they saw the power of the Romans thus threatened by the Etruscan forces. The Plebeians fought side by side with the Patricians in these battles, but the Patricians filled the ranks of the officers and the Plebeians were only common soldiers. The stress and misery caused by these wars fell mainly on the Plebeians, who were most of them either labourers or small farmers, and thus the division between the two classes was inevitably impressing itself more and more on the Plebeians, was making them feel their position intolerable, and inspiring them with readiness for almost any manner of revolution.

The Tribunes. Then, for the first time in Rome's history, some sixteen years after the expulsion of the Tarquins, the Plebeians formed an organisation to protest against the existing system. The Roman legions had just returned to Rome, after a conquering campaign, when they received a command to prepare for a second expedition. The legionary soldiers were all Plebeians, and at this serious crisis resolved to act together for their common interests. Reforms had for some time been promised them, and they now demanded that these reforms should be made realities. The Patricians would not yield as yet, and the victorious legions therefore withdrew from the city and took up their position on a hill some miles outside, a hill afterwards known as Mons Sacer, or the Sacred Mountain. The Patrician rulers found that the time had come when it was no longer possible to avoid making some concession, and they asked the legions to make known the terms on which they would return to the service of the State. The demand of the Plebeians was that certain magistrates should be appointed from the unprivileged orders to protect the interests of the people. There was nothing for it but to yield to these demands. Two Plebeian magistrates, designated Tribunes of the people, were appointed, having as their function and their right the protection of the interests of their own order.

The Land Question. This new system was adopted—had to be adopted—by the ruling class. One concession to justice and fair play naturally led to another, and after a while the number of Tribunes was increased to five, and later still to ten. These Tribunes became a rival ruling power to the Patrician oligarchy and played a most important part in the succeeding history of the Republic. For fully two centuries this struggle is told of in the Roman records. Every improvement in the condition of the Plebeians enabled the working classes to obtain better terms for their labour and especially better terms with regard to the occupation and possession of land. The land question was among the Romans of those early days, as it has been at one time or another in the history of every State, a subject of fierce dispute and agitation. Rome was continually acquiring by conquest large extents of neighbouring land, and it was the custom among the Patricians to divide this land among themselves, and make use of it as their own property. There were among the Patrician order some men of advanced and enlightened views, who bravely and steadfastly advocated the rendering of full justice to the Plebeian order and the establishment of equal citizenship.

An Attempt at Reform. At all periods, such men have been seen in every Patrician oligarchy, just as there have been men found among the leaders of great popular revolutions who did their best to secure just and even merciful treatment for their subdued oligarchical opponents. Some of these reformers among the Roman Patricians endeavoured to bring about a change in the land system by proposing that the Plebeians as well as the Patricians should be allowed a share in the public land. One of these reformers made himself thus so dreaded and detested among the Patricians that an absurd charge was brought against him of endeavouring to attain for himself regal power, and on this charge he was tried, convicted, and put to death. Such misdeeds as this, committed by the holders of power, do not always give to that power an extension of lease, and sometimes have the effect of drawing public attention more suddenly and sharply to the conditions of the lease itself.

Continued

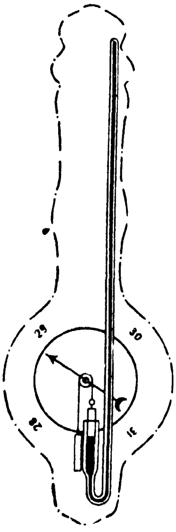
THE PHYSICS OF FLUIDS

Fluid Pressure. The Laws of Fluids. The Barometer. The Syphon. The Pump. The Hydraulic Press. Fluids in Motion

Continued from page 1031

By Dr. C. W. SALEEBY

Fluid-Pressure. In the language of physics, it must be remembered that both liquids and gases, since they flow, are included under the term of fluids. The most important instance of fluid-pressure—the most important fact about fluids—is the atmospheric-pressure. Every one has heard the phrase, "nature abhors a vacuum," but the phrase is far too metaphorical to lead to the truth, and it was not until the time of Galileo that the explanation of the fact was discovered. The credit for it indeed lies with his famous pupil Torricelli. It was found that water would rise about 30 ft. in a pump, but no pump could draw water from a depth of 50 ft. Now, mercury is many times heavier than water, and Torricelli supposed that in all probability mercury would rise in a similar way to water, but to a much less height in proportion to its greater weight; and he was right. If we take a long glass tube closed at one end, fill it with mercury, and then turn it upside down in a vessel containing mercury, we find that all the mercury does not run out of the tube; on the contrary, the mercury sinks in the tube only to such an extent that there remains in the tube a column of mercury which is at a height of about 30 in. above the level of the mercury in the vessel. This is the famous Torricellian experiment, which demonstrates the fact that the atmosphere has a pressure; for the only possible difference between the long column of mercury in the tube and the mercury in the vessel is that the one is exposed to the atmosphere and the other is not. The column of mercury in the tube is supported by the pressure of the atmosphere on the mercury outside it. The space in the tube above the level of the mercury is as nearly a perfect vacuum as can be obtained—that is to say, it contains scarcely any air at all. It is known as a *Torricellian vacuum*. Only a few years after the first experiment of Torricelli, the celebrated writer Blaise Pascal made the experiment of carrying one of Torricelli's tubes to a great height, and found that at the top the level of the mercury was considerably lower. He further found that as he came down the level of the mercury rose, and thus it was plainly shown that the atmosphere possesses a pressure and that this pressure lessens as we ascend in it.



MERCURIAL BAROMETER

The Barometer (from the Greek *baros*, weight, and *metron*, measure). The reader will have already seen that the Torricellian tube is a barometer—that is to say, an instrument for measuring the pressure of the atmosphere. That, of course, is all that a barometer does; it tells us nothing about the weather directly, but is of use in this connection merely because the state of the atmospheric pressure at any given time is by far the most important factor in the determination of the weather.

Torricelli's tube, however, is a very inconvenient barometer, and it is more convenient to have a U-shaped tube, constituting what is called a syphon barometer. This, again, may be easily modified so as to give us what we call a weather-glass. If we place an iron ball so as to float upon the mercury at the open end of the tube, and attach a string to the ball, and a weight to the end of the string by way of balancing the ball, we can conveniently pass the string over a wheel, and to the wheel we can attach a pointer; this pointer can then be made to indicate such legends as "set fair" or "changeable" printed on a circular card. The principle of Torricelli may be employed in a number of different forms, such as the Kew barometer, the marine barometer, and others which do not concern us here. But we may also measure the fluid pressure of the atmosphere by means of another instrument which is much less fragile, since it contains no mercury or glass.

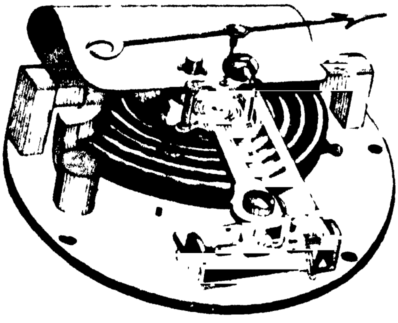
Aneroid Barometer. The aneroid barometer—literally meaning a barometer that contains no liquid—simply consists of a round, flat metal box emptied of air, and having a spring attached to it. The varying pressure of the atmosphere causes the top and the bottom of the box to approximate to one another in varying degrees, which are recorded by the spring, and this spring moves a pointer by means of a lever. The aneroid is quite a convenient little instrument, but it has comparatively small pretensions to accuracy.

When accuracy is wanted it is necessary to correct the readings of even the mercury barometer in various ways; of these the most important is the correction for temperature, so that a first-class barometer always has a thermometer with it. It is hardly necessary to say that the mercury expands as the temperature rises, and unless this were allowed for, we should get the impression that the atmospheric pressure was higher than was actually the case.

The most important points in the construction of a barometer are to make certain that the mercury is pure and absolutely clean, and to boil it. By this last precaution we expel all air and moisture which would otherwise tend to accumulate in the Torricellian vacuum, and would thus make the reading unduly low.

The atmospheric pressure is a direct result of the earth's gravitation, and is simply an expression of the fact that the air has weight, and thus exercises a pressure on anything that may be immersed in it. The English "Standard Atmosphere"—the word atmosphere or sometimes "atmo," is now used in this fashion—is taken as equivalent to the weight of a column of pure mercury 30 in. high, or about 14.7 lb. to the square inch. This is taken at Greenwich, whilst the French take their standard at Paris. Owing to the fact that the earth is not a true sphere, and thus the various points on the surface of the earth are not all at the same distance from the earth's centre, it is necessary when exactness is required to state the latitude where the reading of the barometer has been taken.

Effects of Atmospheric Pressure. Every square inch of our bodies is thus constantly exposed to a pressure of more than 14½ lb., though we are entirely unaware of it, and feel no discomfort. This is essentially due to the fact that the pressure is the same in all directions. It weighs down upon our heads, but it also supports us on all sides. This fact, that *the pressure of a fluid is the same in all directions*, is not only of cardinal practical importance to all, but is also of great interest, as we shall soon see, to the student of physics. A very simple experiment will demonstrate the fact of atmospheric pressure upon ourselves. There is a simple little operation known as "dry cupping," which consists in removing part of the air from a test tube or from a tumbler, as, for instance, by burning something in it, and then suddenly clapping it down upon a portion of the skin. In a very short time, as the hot air inside the vessel cools and contracts, and thus causes a lowering of the atmospheric pressure upon that area of skin as compared with the area that is not covered by the vessel, the covered part begins to swell and rise up into the vessel; this is simply due to the fact that the fluids under the skin are forced by the relatively high pressure exercised upon all the other parts of the body towards the area which has been relieved of part of its pressure.

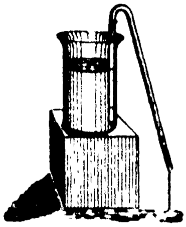

ANEROID BAROMETER

The atmospheric pressure is also of cardinal importance to us in that it is a necessary condition of ability to breathe. Our lungs have no power of deliberately helping themselves to the air that we need. The requisite air passes from the atmosphere into our blood by purely mechanical action, due to the fact that the gaseous pressure in our blood—the atmospheric pressure, if you like—is much lower than the gaseous or atmospheric pressure outside it. But, as readers of the course of CHEMISTRY have already learned, the atmosphere consists of a number of gases, and each of these exercises its own *partial pressure* in proportion to the quantity of it that is contained in the atmosphere. Thus, while the partial pressure of the oxygen in the atmosphere is higher than that of the oxygen of our blood, and thus causes the oxygen in the air to pass into the blood, the partial pressure of the carbonic acid in the atmosphere, on the other hand, is less than that of the carbonic acid in the blood, and thus the carbonic acid passes from the blood outwards to the atmosphere.

Applications of Atmospheric Pressure. The ways in which the atmospheric pressure may be utilised are very numerous, and the most important of them were employed long before they could be explained. A familiar instance is the boy's sucker, a bit of soft, moist leather, with a string attached to its middle point. It is the atmospheric pressure that enables the edge of the sucker to adhere to a smooth stone or other object, which can thus be picked up. Another familiar illustration of the action of atmospheric pressure is shown in the trick of turning upside down a tumbler full of water covered with a card without the water running out. The explanation of this is plainly that the weight of the water upon the inner surface of the card is counterbalanced by the weight or pressure of the atmosphere on its outer surface.

The Syphon. If we take a U-shaped tube and fill it with water, and then immerse one end of it in a vessel of water, having the other end of it below the level of the water in the vessel, the water will be drawn from the vessel and runs out of the lower end. This simple apparatus is called the *syphon*. The explanation of this action is very simple. The water in the second half of the tube, which is turned downwards, naturally tends to run out; but if the water which is at the bend of the tube did not follow there would be a vacuum formed there, and so the atmospheric pressure forces the water in the vessel up the first part of the tube. If, however, the height of the bend were greater than the distance to which the atmospheric pressure can force a column of water, the syphon would not work. That distance, as we saw at the beginning of this section, is about 30 ft. This can be proved if, instead of water, we employ mercury in the syphon, and then put it under an air pump. When the air is pumped out and the pressure thus reduced, the mercury ceases to flow through the syphon.

The student of practical chemistry is familiar with a little glass tube, sometimes graduated, which is called a *pipette*. The straw through which one sucks lemonade is really a pipette. When by sucking one end of the tube we remove the atmospheric pressure upon that end, and allow it to act exclusively upon the lower end, it forces the liquid up into the tube. If, then, we put a finger upon the top of the tube or close the top of the straw with the tongue, we are able to hold the liquid in the tube, just as the mercury is held in a barometer. The principle of the little syringe with which one prepares to fill a fountain pen, or of the superior syringe which has a piston, is exactly the same. Remember that the atmospheric pressure has a limit, or, as someone has remarked, by way of ridiculing the old-fashioned way of talking, "there is a limit to nature's abhorrence of a vacuum." You could not draw up 40 ft. of water in a syringe.



SYPHON

The Pump. The pump is really a special kind of syringe. As far as its principle is concerned, it is nothing more. We require only some mechanical arrangement so that the water which is raised by the atmospheric pressure, when the piston ascends, shall be discharged at the point required when the piston descends. For this purpose we must have a couple of valves both opening upwards, one in the piston, and the other at the bottom of the cylinder which contains the water; and thus when the piston goes down, the water passes through the valve in the piston and escapes by the spout. The force pump approximates more closely to the syringe, for in this case the plunger is solid and the only difference between the two is that, whereas the fluid escapes from the syringe by the same opening as that by which it entered, the force pump has a valve at the bottom of the cylinder opening upwards and an escape pipe at the same level. An instance of the combination of the two methods is furnished by the breathing arrangement of the frog, which consists of a combination of a suction pump and a force pump. The first part of the act of breathing consists in sucking air into the mouth, for which purpose the floor of the mouth drops, as everyone who has observed a frog must have noticed, and thereafter the floor of the mouth is raised and the air is forced into the animal's lungs.

The Laws of Fluids. In discussing the physics of fluids we first of all took up the laws of fluid-pressure by way of an introduction to the subject, since they yield us many interesting facts of practical moment. But now we must go more into the details of the laws which govern the behaviour of fluids, taking first of all the laws of fluids at rest. The technical name for this branch of physics is Hydrostatics; the first part of this word is derived from *hudor*, the Greek word for water. The following are the three great laws of hydrostatics:

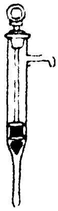
(1) Fluid-pressure is always exerted at right angles to any surface which is exposed to it.

(2) At any point in a motionless fluid the fluid-pressure acts with the same intensity in every direction.

(3) The weight of the fluid being neglected, the fluid-pressure is the same at all points in a fluid mass.

The First Law. The first of these laws depends really upon our definition of a perfect fluid. By a perfect fluid we mean one which is perfectly mobile—that is to say, one which is incapable of exercising any oblique pressure upon a surface. Such oblique pressure would be due to the action of friction, and if the fluid be perfectly mobile there can be no friction to act.

Another way of putting this is that a perfect fluid offers no resistance to *shearing stress*. It must be remembered, however, that we cannot experiment with perfect fluids in practice. The fluids we know are not perfect in this sense; they have a certain amount of viscosity—or "oiliness," to use a popular expression and thus offer a considerable resistance to objects passing through them—a resistance which is more than the result of fluid-pressure as such, but partakes of the nature of friction. The resistance of the air has already been spoken of in dealing with the first law of motion; such resistance is not the result of fluid-pressure at all, but of the fact that the air is not a perfect fluid in the sense we have defined. Still less is water a perfect fluid, though the amount of resistance which it offers to the surfaces of a knife passed through it edge foremost is certainly very slight; but if we are to reach the true laws of fluids we must exclude the action of friction, and so we must conceive of a perfect fluid which offers no resistance to any body, save the resistance which is exerted strictly at right angles to the surface of that body, and which is a result, not of its physical condition, but of fluid-pressure.



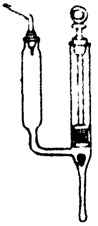
LIFT PUMP

The Second Law of Hydrostatics. The law of the equality of fluid-pressure in all directions was discovered by the French philosopher Blaise Pascal, and is sometimes known as Pascal's principle. It may be reached in two ways—a very conclusive proof of its truth. It may be reached by purely mathematical means which are able to demonstrate that, given the definition of a perfect fluid, the pressure at any point within it must be the same in all directions. But it can also be demonstrated by means of experiment. In the language of logic, we say that the first mode of proof is *a priori* or deductive, whilst the second is *a posteriori* or inductive. We can be absolutely content with our proof of any statement in natural science only when both these methods agree in demonstrating it.

Perhaps the simplest of the many experiments which may be made in order to prove the truth of Pascal's principle is that of corking an empty bottle and weighting it so that it sinks into deep water; it will then be found that the fluid-pressure forces the cork into the bottle and that this occurs in exactly the same way whether the bottle be upright or turned upside down or at whatever angle it be placed.

Plainly, this law implies that a fluid exerts an upward pressure as well as a downward one, but it is as much a mistake to think that a fluid has a definite tendency to force things upwards as to force them downwards. Its pressure is absolutely impartial; this is the cardinal difference between fluid-pressure and the pressure exerted by one solid body on another. This last is exerted in one definite direction only.

The Hydrostatic Paradox. Now, it follows from the above laws that a very small amount of fluid can be made to support an indefinitely great weight in virtue of the fact that the pressure exerted by the small amount of water can give rise to a great force if it be applied to a wide surface. The pressure exerted by a small amount of water communicating with a reservoir of water is transmitted through it, and is felt and is exerted at every point on the surface of that reservoir. This may be technically phrased thus: if we fill with fluid a closed vessel with plane surfaces—plane meaning flat, of course—and then exert a small amount of force on a small surface of the liquid—say, a square inch—an equal force is exerted on every square inch of the flat surfaces in question, and thus the force is multiplied. Hence it is that the force exerted by a very small amount of water may be able to support a weight indefinitely great. The term *paradox* has been applied to this fact because it seems at first sight impossible that power can thus be multiplied. The truth is that power is not multiplied. No mechanical or other arrangement can multiply or destroy power. What some arrangements can and do constantly multiply is not power or energy, but *force*—a word which is technically used in physics to mean one thing and one only—namely, the ability to do work. Thus the hydrostatic paradox so called is really no more a paradox than the action of a lever or a pulley, or any other mechanical arrangement for multiplying force.


FORCE PUMP

PRINCIPLE OF HYDROSTATIC MACHINE

The Hydraulic Press. This is often called the Bramah Press, after the man who effected an important improvement in it. It consists essentially of a strong piston working up and down in a strong cylinder. Into the cylinder there leads an inlet from an ordinary force pump; the piston of this force pump is quite small and can easily be worked by a man, but the force he exerts is greatly multiplied in proportion to the ratio between the size of the piston which he is working and that of the large piston of the Bramah Press. The work done on the pump by the man is precisely equal to the work done by the press; there is no multiplication of power. In order that there should be a real multiplication of power—such as we have said is impossible—the speed of the large piston of the press would have to be the same as the speed of the small piston of the force pump which the man is working. There would then indeed be a creation of power, but this is not so. The piston speed of the pump has to the piston speed of the press exactly the ratio that the area of the press has to the area of the pump. In other words, suppose the piston of the press to be 20 times as large in area as the piston of the pump, it will then move at only one-twentieth of the speed. The mechanical advantage of the machine is that speed is not what is wanted in the press; the speed which in the pump is the direct result of the man's work is translated into force in the press.

The Two Kinds of Fluids. So far we have been able to speak of fluids in general without distinguishing between them, and we have been able to state laws which are true of all fluids. But the reader may have already been somewhat astonished at the inclusion under one term of two things so very different as water and air, and it is now time to distinguish between the properties of two fluids so very different as water and air. The two kinds of fluids are liquids and gases. So far as the laws of hydrostatics are concerned, there is no distinction between them. It is this fact that has led to the abandonment of the old term pneumatics which we have not employed. It is really superfluous, since the general conditions of fluid equilibrium are, as we have seen, identical whether the fluid be liquid or gaseous.

Compressibility of Fluids. It used to be stated that the essential difference between a liquid and a gas is that the first is incompressible, whilst the second is compressible. A gas can be squeezed into a small compass, and when the pressure is relaxed it expands again. It is readily compressible. But if we put some water into a syringe and attempt to squeeze it into a smaller space we find that it is apparently incompressible. There is thus a very great distinction. It is now a long time since the incompressibility of liquids was demonstrated. Bacon, for instance, filled a leaden shell with water, and then hammered and squeezed it in the hope that he would be able to compress the water, but instead it oozed through the lead. Similar experiments were made long ago in Florence, globes of silver and of thickly gilded silver being employed, but always the water oozed through rather than suffer compression.

As to the distinction between liquids and gases, it is necessary to state that liquids are, after all, compressible, though almost infinitely less so than gases. The compression of water is only perceptible under exceedingly high pressures. It is estimated that water is compressible to the extent of about ·00005 of its volume for every atmosphere of pressure.

Boyle's Law. We now come to a very celebrated law dealing with the pressure of a gas which was discovered by the Hon. Robert Boyle in the seventeenth century, and is now known by his name. Boyle proved in his experiments "touching the spring of the air," that the volume of a given mass of gas depends on its pressure. Boyle's law may be stated in several forms. Perhaps the following is the simplest: If the temperature be constant the volume of a gas varies inversely as its pressure. This fact may be expressed in another way. For a given quantity of gas the product of the pressure and the volume is constant. The most popular statement of the law would run something like this: If we take a given quantity by weight of any gas we find that the greater the space it occupies the less is the pressure it exerts, and *vice versâ*.

This exceedingly simple law may be taken as true for all practical purposes, but it has recently been found that it is not absolutely true in all cases; especially it is found that at very high pressures the law is only approximately, not absolutely, observed.

A cardinal difference between liquids and gases is that the latter alone always fill any space that may contain them. You cannot take a small quantity of air and put it in the bottom of a vessel and expect it to remain there; it will expand so as to completely fill the vessel, no matter what its size may be. This fact, of course, is naturally associated with Boyle's law. Upon it depends the principle of the air pump. For if we connect an empty vessel with a vessel containing air the air will at once fill both of them, and thus by a simple mechanical contrivance it is possible to reduce the amount of air in the vessel to an indefinite degree.

The Air Pump. Hence, we have the air pump, and the first point we notice about it is that we can never hope by this means to extract all the air from a vessel. Every time the pump is worked we can extract perhaps half the remaining air, but if we follow this out it will be seen that such a process will never result in completely emptying the vessel. If you owe a man a shilling, and proceed to pay him first sixpence, then threepence, then three-halfpence, and so on, halving the amount of your payment each time, the debt will not be paid even in infinite time; and the case of the air pump is similar. Hence a perfect vacuum can never be thus obtained; but a vacuum which is almost perfect can be obtained by the simplest possible means, and this is the Torricellian Vacuum, which was described when we were dealing with atmospheric pressure and the barometer. The space left at the top of the closed glass tube there described contains nothing but a very small quantity of the vapour of mercury.

In contradistinction to the behaviour of a gas, which always fills any space in which it is contained and which thus enables us to make air pumps, is the behaviour of a liquid, which always has a free surface. Such a surface is horizontal or level—at any rate, we describe it as such, and such it is for practical purposes; but as a matter of fact the surface of a liquid, even water in a tumbler, is not horizontal or level, but is curved, having a convexity which corresponds to, and is indeed part of, the general convexity of the earth. Every part of the surface of a liquid is at the same distance from the earth's centre, and thus the surface cannot be absolutely level, though it is practically so. If we place in a vessel two liquids which cannot mix, such as oil and water, we similarly find that the surface between the two is practically horizontal. The same thing is true in the case of gases. After an explosion in a coal-mine, the carbonic acid, as the miners well know, being heavier than air, seeks its own level, and fills the lower part of the workings.

A large number of considerations in hydrostatics have already been dealt with, amongst these being the principle of Archimedes, the equilibrium of floating bodies, and the whole question of specific gravity and hydrometers.

Physics of Fluids in Motion. As the reader would expect, this part of our subject is known as Hydrokinetics; it is one of the most recondite parts of physics, and it is largely in order to simplify, as far as possible, the study of it that physicists have invented the conception of a perfect fluid, since, when friction and viscosity are taken into account in the study of fluid motion, the whole subject becomes practically too difficult for prosecution; even the motion of perfect fluids is to be investigated only with very great difficulty. Perhaps the most important proposition in hydrokinetics is that arrived at by Torricelli, Galileo's famous pupil. It deals with the speed at which water flows out of an opening in a vessel. The student will be prepared to believe that the rate at which the fluid, say water, flows out will depend upon its pressure, and its pressure will plainly depend upon its weight. We can measure the speed at which water will fall freely from a height, and Torricelli showed that the speed with which the water will issue from the opening corresponds to a fall from the height of the surface of the water above the opening through which it issues. But complications arise. For instance, the actual speed at which the water emerges varies very greatly with the shape of the opening.

The pressure of moving liquids is a subject too complicated to be treated in such a course as this. But it is an exceedingly important subject, and its importance has greatly increased in late years. Upon the pressure of moving liquids depends the turbine, and, as the reader is aware, this form of motor is now rapidly superseding all its predecessors in naval engineering.

Limit of Speed Through Water. The last point to which we need refer is one to which allusion has already been made; it concerns the limits of attainable speed through water. The task which has to be performed by the engines of a ship is to overcome the resistance of the water—more accurately, we should say, by the engines of an already moving ship. Once the ship is in motion, as we have seen in our study of Newton's first law, it will continue to move for ever but for the external resistance, and it is that resistance that the engines have to overcome. Now, it might at first be thought that if engines of 1,000-horse power can develop a speed of, say, 10 knots an hour, then in order to develop double that speed it will be necessary merely to double your horse-power; but this is very far from being the case. In the first place, the resistance of the water to the vessel increases, not as the speed increases, but as the square of the speed—that is to say, if you double the speed, you quadruple the resistance. Further, it is obvious that the distance through which the resistance is overcome in a given time varies according to the speed. Hence, it follows that the horse-power necessary for any vessel must vary according to the *cube* of the speed desired. In other words, if you wish to double the speed of the vessel, you require, not twice the horse-power that you had before, but eight times the horse-power, eight being the cube of two.

THE PROPERTIES OF MATTER

Molar and Molecular Forces. The reader will be rather astonished, perhaps, to observe the title of the section we now introduce. What have we been talking about hitherto, he may say? Certainly we have been talking about matter, but we have been concerned with matter in general, and with the forces which are displayed in and by matter. Similarly, in discussing motion there has been implied the idea of the matter which moves. Nevertheless, there are certain important properties of matter to which we have scarcely alluded. Physicists often employ two very convenient words in order to distinguish between the forces and properties which are to be discussed in the present section. These words are *molar* and *molecular*. The first of these words is derived from the Latin *moles*, a mass, and the second word is the adjective derived from the word molecule, which literally means a little mass. Now, in the course on chemistry a very careful and important distinction has been drawn between the word atom and the word molecule, but it was also pointed out that the use of the word molecule had been altered in recent years. It was noted that nowadays the word molecule is applied to a combination of atoms, whereas only a few years ago the two words were synonymous. Now, when the physicists speak of molecular forces they are using the word as much in the old sense as in the new. The reader who comes to this section, after having studied in the course on Chemistry the difference between the meanings of atom and molecule, is entitled to expect that when we come to speak of molecular forces we mean the forces displayed by molecules as distinct from atoms. But, in point of fact, the forces of which we are to speak are in some cases really molecular in the precise modern meaning of the term, but are not infrequently atomic. Only too often the physicist is not prepared to say whether these forces, and these peculiar properties of various kinds of matter, are due to the character of the molecules, or to the character of the atoms that go to make up these molecules. So much for one of the many explanations that are necessary in consequence of changes in the use of words.

Chemical and Physical Differences. Now, we must have even another explanation. In the very first page of our course we distinguished between physics and chemistry by declaring that, whereas chemistry deals with particular kinds of matter, physics deals with matter in general, and that distinction is perfectly true. Chemistry seeks to analyse the various kinds of matter and reduce them to what are called their elements, and then it proceeds to take these elements one by one, and to discover all that may be known about each of them. The forces and properties with which chemistry has to deal are thus said to depend on the chemical composition of whatever substances it may be studying. But, in addition to these chemical forces, there are a number of other kinds of forces displayed in certain kinds of matter which do not at all depend upon the chemical composition of the matter in question, but upon its *physical state*. Familiar instances of the distinction we are seeking to recognise may be furnished by water and carbon. So far as the chemist is concerned, water is still water, consisting of constant proportions of hydrogen and oxygen, no matter whether it be liquid water or solid water or gaseous water. But the physicist is profoundly interested in the differences between these three kinds of water. There is no *chemical* difference, we observe, between ice and water vapour; the chemical composition of each is the same, but the physical difference between them is profound. Or, again, take carbon; the diamond and charcoal, and the black material in a so-called lead pencil, these all have the same chemical composition—they simply consist of carbon. But the physical differences between them are very great indeed, and are deeply interesting to the physicist. The chemist says that the kind of matter in each of these three specimens is one and the same; and that, of course, is an exceedingly important fact. But here the physicist takes up the discussion, and says: "I thank you for this extraordinary discovery that diamond and charcoal and graphite all consist of the same kind of matter; but now I am going to inquire what it is that enables one and the same kind of matter to show itself in such profoundly different forms as diamond and charcoal, or as ice and steam. The kind of matter is the same, the atoms and the molecules are identical, but plainly they must be related to one another—in one way in diamond, and in another way in charcoal. The differences are not chemical, but physical."

Continued

Continued from page 1019

THE ORDNANCE SURVEY

History and Scope of Ordnance Survey Maps. Land Measurements in Great Britain and Abroad. Metric System of Measurements

By A. TAYLOR ALLEN

History. The Ordnance survey is a trigonometrical survey of the United Kingdom, and is performed by officers and men of the Royal Engineers.

Apart from all scientific and other considerations, it must be admitted that this survey of the United Kingdom has, so far as the public is concerned, more than fulfilled the object it was intended to accomplish. It is, in fact, the only reliable survey of the country that is published and available for reference.

The preparation by the Government of a general map for any portion of the country was first proposed after the rebellion of 1745, when the want of a reliable map of the northern parts of Scotland was much felt by Army officers. This was the first State survey of any portion of the King's dominions that was ordered for military purposes. This extensive work was entrusted to Lieutenant-General Watson, the Deputy Quartermaster of Great Britain, who, with the aid of Major-General Roy, was engaged for 10 years in executing the work. The map was drawn to a scale of 1¼ in. to the mile, but it was never published. Twenty-nine years elapsed before any other portion of the country was surveyed by the State, and then the work was undertaken for scientific, rather than for military, purposes It was with the object of calculating the difference of longitude between the observatories of London and Paris that, in 1784, General Roy measured a base-line on Hounslow Heath, which started a series of triangles extending to Dover.

Origin of the Present Ordnance Map. A few years later the Government decided upon having a general survey of the United Kingdom prepared for military purposes. This was the origin of the present 1-in. Ordnance map, and the triangulation carried out by General Roy in the south-eastern counties became the basis of the general triangulation. As the survey was extended westwards it was considered advisable to measure another base-line. This was done on Salisbury Plain, and for purposes of verification other lines were measured, at Misterton Carr, in 1801, and Rhuddlan Marsh, in Flintshire, in 1806. The first sheet of this survey was published in 1801. About this period the public utility of State charts for purposes other than those of a military character began to be recognised. The public demand for better maps than were then available became so great that surveyors were engaged for the purpose of pressing forward the completion of the 1 in. survey that was then in hand.

The principal triangulation in Scotland was commenced in 1809. But little progress had been made when the officials and surveyors were withdrawn to enable them to carry forward the detail maps of England. Going north again in 1813, the work was pushed steadily forward for six or seven years. In the three following years the Scottish survey, although not altogether suspended, made but little headway.

The survey of Ireland was required for political and administrative purposes, and the Government decided that the map should be prepared to the scale of 6 in. to the mile, and the chief strength of the surveying corps was transferred to Ireland for this purpose. The map was completed in 1845.

The value of this 6-in. map having been proved, a survey for a similar map was commenced in the northern counties of England in 1840, and in the following year secondary operations for a map of Scotland, also on a larger scale, were begun, but in 1851 a committee of the House of Commons recommended that the 6-in. maps be stopped and the 1-in. maps completed in detail.

Triangulation of the United Kingdom. The primary triangulation of the United Kingdom was finally completed in 1852. It comprises in all 250 trigonometrical stations, and a map showing all these lines, which is very seldom seen, presents the appearance of a huge spider's web, with its centre laid on Salisbury Plain. The average length of the sides of the triangles is 35·4 miles, and the longest measures 111 miles. The accuracy, or otherwise, with which the triangulation was carried out was at one time tested, with extremely satisfactory results. The length of the base-line measured in Ireland on the border of Lough Foyle was calculated through a series of triangles from the base on Salisbury Plain, and the length so found differed from the measured base by only a little more than 5 in. The distance apart of these two bases is about 360 miles, and their length about 41,614 ft. and 36,578 ft respectively.

From the opinion of a large number of the most eminent scientific and practical men it was found that the great preponderance of opinion was in favour of a scale of $\frac{1}{2500}$th, or nearly 1 in. to the acre. This scale was therefore ordered in May, 1855.

The charge of the Ordnance survey was transferred to the Board of Agriculture on its formation in 1890.

Maps and their Uses. The standard maps published by the Ordnance Survey Department, and obtainable from Edward Stanford, of 12, 13, and 14, Long Acre, W.C., the sole London agent, and from the Ordnance Survey Office, Southampton, are as follows.

General Map. A *general map* of the whole of Great Britain and Ireland on the scale of 1 in. to 1 statute mile, and prepared on one uniform system. On the coloured maps the county boundaries are shown by a softened band of colour. The larger parks are green, the principal roads brown, the rivers and canals blue, and the railways red.

There are two series for England and Wales, known as the New Series and the Original Series. The New Series is published in sheets engraved in outline with contour lines. The size of the work on the sheets is 18 in. by 12 in., representing 18 by 12 miles. The Original Series is published partly in sheets and partly in quarter sheets, hills being shown by vertical hachures.

This map is of use principally as a road map. It is too small for any great detail to be shown. It is the cyclist's favourite scale. Steps have been taken to ensure that each sheet shall be revised every 15 years. The second revision has already begun.

County Maps. *County Maps*, on the scale of 6 in. to one statute mile, engraved or drawn, and published in sheets and (for certain counties) quarter sheets.

A full sheet represents 6 miles by 4 miles, and contains 15,360 acres. A quarter sheet represents 3 miles by 2 miles. The sheets of each county are numbered horizontally by Roman numerals.

The quarter sheets bear the numerals of the full sheet, of which they form a part, with the addition of the initial letters N.W., N.E., S.W., S.E., according to the position they occupy on the full sheet.

These county maps show more detail than the general map, but are not large enough that any accurate work may be set out from them, but very valuable for estate purposes.

Parish Maps. *Parish Maps*, on the scale of $\frac{1}{2500}$th, or 25·344 in. to 1 mile, which is approximately equal to 1 acre for every square inch on the map. A sheet represents 1½ miles by 1 mile, and contains 960 acres. Sixteen plans on this scale form one 6-in. full sheet, and bear a double reference number.

This is the best size for general work. The smaller scales are too close, and the larger ones make very cumbrous maps, if, say, for an estate, two or three are joined together.

Town Maps. *Town Maps*, on the scale of $\frac{1}{500}$th, or 126·72 in. to 1 mile, or 41·66 ft. to 1 inch, which is adopted for all towns of more than 4,000 inhabitants. Each plan represents 24 chains by 16 chains, and contains 38·4 acres, and shows the arrangement of the beds in the gardens.

The sheets of these maps bear a treble number. Maps of certain towns have been published on the scale of $\frac{1}{528}$th, or 10 ft. to 1 mile, and many on the scale of $\frac{1}{1056}$th, or 5 ft. to 1 mile. A scale of 88 divisions to 1 in. is applicable to the latter map.

The map of the United Kingdom, on the scale of $\frac{1}{1000000}$th, is expected to be published during the current year. It is claimed that it should be useful as a wall map and for educational purposes.

Maps for Schools. A new departure has been made in the supplying of schools with specially printed Ordnance Survey maps at a very low price. These maps are issued on a written undertaking from the headmaster, or other responsible representative of the school, that they will not be placed on sale, and will be used for educational purposes only. Over 46,000 of these maps were supplied in 1903-04.

Engineers and surveyors find the Ordnance maps and area books absolutely necessary for much of their work. The Ordnance Survey reference books give the area of every field and enclosure to the thousandth of an acre, in acres and decimals.

A résumé, giving full particulars of all the Ordnance and geological survey maps, plans, etc., can be obtained from the agents for the sale of maps.

Edward Stanford	..	London.
J. Menzies & Co.	..	Edinburgh.
Hodges, Figgis & Co.	..	Dublin.

Ordnance Datum. The bench marks of the Ordnance surveys are of this pattern ⊼ and are known as Ordnance bench marks (O.B.M.).

The horizontal line represents the spirit level, and the three strokes forming the arrow represent the legs of the stand of the level (technically known as the tripod). On the sheets of the Ordnance Survey the levels of the several bench marks are numbered in feet and decimals of a foot above mean high-water mark at Liverpool, which is assumed to be 0·650 of a foot below the general mean level of the sea. These heights have been determined at many points throughout the country: each is designated by the mark referred to, being in a wall, or footpath, or milestone, at the spot indicated on the Ordnance map.

Land Measures. Originally land measure differed in various parts of England, and was governed by the custom of the particular locality in which the land was situated, hence the term "Customary Measure."

Now, however, land measure for the whole of England is governed by Statutes 34 Henry VIII., 5 George IV., chap. 74, and 5 and 6 William IV., chap. 63; hence the term "Statute Measure."

Consequently, in old documents, one occasionally comes across plans, etc., giving the area of lands in customary acres, roods and perches, and it is, therefore, necessary to reduce *customary* to *statute*, and sometimes statute to customary measure.

The same remark applies also, in some cases, when dealing with land in Scotland or Ireland, or other parts of the world, where the land measure differs from our statute measure.

1. By the Act 5 George IV., chap. 74 (June 17th, 1824), it is enacted: "That our

present yard shall be denominated the 'Imperial standard yard'; and shall be the unit, or only standard measure of extension, whereby all other measures of extension whatsoever, whether the same be lineal, superficial, or solid, shall be derived and computed; and that all measures of length shall be taken in parts, or multiples, or certain proportions, of the said standard yard; and that one-third part of the said standard yard shall be a foot, and the twelfth part of such foot shall be an inch; and that the rod, pole, or perch in length, shall contain five such yards and a half: the furlong, two hundred and twenty such yards; and the mile one thousand seven hundred and sixty such yards"

2. By the same statute it is enacted that all superficial measures shall be computed by the said standard yard, or by certain parts, multiples, or proportions thereof; and that the rood of land shall contain one thousand two hundred and ten square yards; and that the acre of land shall contain four thousand eight hundred and forty such square yards, being one hundred and sixty square rods, poles, or perches.

3. By the Act 5 and 6 William IV., chap. 63 (September 9th, 1835), all *local* or *customary* weights and measures are abolished, not only in England and Wales, but also in Scotland and Ireland.

Multiples of the Yard. The yard being the British standard length, it is multiplied into chains, furlongs, and miles, and divided into feet and inches, the chain of 22 yards being divided into 100 parts, or links, each of which measures 7·92 inches.

In the school table books 5½ yards is called 1 rod, pole, or perch, and the square formed by this length, containing 30¼ sq. yd., is called 1 sq rod, pole, or perch.

Surveyors object to this confusion of terms, and are generally agreed that the term pole shall be used for lineal measure, and perch for square measure, so that areas in land surveying are usually stated in acres, roods and perches, any fraction over being stated as ¼, ½, or ¾, to whichever of these it is nearest.

The Ordnance surveyors use three places of decimals for the fractional perches, giving an appearance of accuracy which the work itself will not warrant, as an allowable error is 1 perch per acre.

Formerly, by custom, the perch varied in different parts of England, and with it, consequently, the acre also varied in proportion In Devonshire and part of Somersetshire, 15 ft., in Cornwall, 18 ft., in Lancashire, 21 ft., and in Cheshire and Staffordshire, 24 ft. were accounted a perch. In the common field-lands of Wiltshire there was a customary measure of a different nature—*viz.*, of 120 instead of 160 statute perches to an acre, so that 30 perches of statute measure made 1 rood of customary, or 3 statute roods made 1 customary acre, or 30 statute perches made 1 rood, and 4 such roods made 1 acre customary measure.

It may be observed that 4,840 sq. yd. make 1 statute acre—3,630 made 1 Wiltshire acre, 4,000 made 1 Devonshire or Somersetshire acre, 5,760 made 1 Cornwall acre, 7,840 made 1 Lancashire acre, and 10,240 sq. yd. made 1 acre of the customary measure of Cheshire or Staffordshire.

The Scotch acre contained 1,244$\frac{1}{9}$ sq. yd., and the Irish acre 3,000 sq. yd. more than the English statute acre; while the Scotch mile was 216¼ and the Irish mile 480 yards more than the English mile.

The standards of measurement in London for testing chains, rules, and rods are situated in the Guildhall and on the north side of Trafalgar Square, and may be used free of charge.

Reducing to Statute Measure. In many old surveys and plans the area is given in local and customary acres, rods, and perches, consequently it is necessary to give the method of reducing local or customary measures of land to statute measure and statute to customary measure.

METHOD No. 1. When the number of feet in a customary perch is given, reduce the customary quantity to square feet, and divide by 272·25, the number of square feet in a statute perch, and again divide the quotient by 160, the square perches in an acre for acres; and the remainder, multiplied successively by 4 and 40, and divided successively by 160, will give the roods and perches statute measure.

METHOD No. 2. When the number of square yards in a customary acre is given, reduce the area (customary measure) to acres and decimals of an acre, multiply by the number of square yards in a customary acre, and divide by 4840, the square yards in a statute acre, and reduce the decimals to roods and perches by multiplying successively by 4 and 40.

Problem No. 1. Reduce 17 a. 0 r. 9 p. customary measure, when the customary perch is 15 ft., to statute measure.

```
                                  a  r. p.
Area, customary measure          17  0  9
Roods in an acre . .      . .     4
Customary roods           . .    68
Perches in a rood         . .     40
Customary perches         . .   2729
Sq. ft. in customary perch       225
                               13645
                               5458
                              5458
Statute feet in      272·25)614025·00(2255 -
  statute perch               54450            statute
                               69525           perches.
                               54450
                               150750
                               136125
                                 146250
                                 136125
                                  10125
```

```
Square perches  160)2255(14 0 15 are a statute
  in 1 acre       160                 measure.
                   655
                   640
                    15
                     4 roods
                 160)60(0
                     40
                 160)2400(15 perches
                     160
                      800
                      800
```

Problem No. 2. Reduce to statute measure :6 a. 1 r. 10 p., when the customary acre contains 36,000 sq. ft.

```
                               a.  r.  p.
Area, customary mea-
  sure                         16  1  10
                 16 and         50
                               160 acres
                                16·3125 acres
Yards in customary acre              4000
Yards in statute acre   484·0)65250·0000(13·4814
                                484
                                1685
                                1452
                                 2330
                                 1936
                                  3940
                                  3872
                                    680
                                    484
                                    1960
                                    1936
                                      240
                  13·4814
                        4
                   1·9256
                       40
                  37·0240
```

Area, statute measure: 13 a. 1 r. 37 p.

To reduce statute to customary measure the process is, of course, precisely similar, only the multipliers and divisors are transposed.

Foreign Miles.—The miles recognised as standard in foreign countries vary, and are as follows.

Denmark	7,233	English yards.
France (small degree) ..	2,933	..
.. (mean degree) ..	3,666	..
„ (large degree) ..	4,400	..
Germany	5,866.	..
Ireland	2,240	..
Italy	1,467	..
Poland	4,400	..
Russia	1,110	..
Scotland	1,976½	..
Spain	5,028	..
Sweden	7,233	„

French Measures. The French system of measuring is easy to comprehend, it being necessary to remember only the are, mètre, and stère. The others are all related in a tenfold proportion, the preceding part of the word making the distinction, the terminations all being the same—decamètre, hectomètre, kilomètre, etc., signifying 10, 100, 1,000, etc., times the mètre; and decimètre, centimètre, millimètre, signifying 10, 100, 1,000 parts of the mètre.

We append a table showing English standard equivalents of lineal, superficial, and cubic measurements in the metric system, and the metric equivalents of the English standards. It is a simple matter to reckon out these equivalents from one system to the other with an accurate table as a basis of calculation. For instance, hectares may be reduced to acres by multiplying by 2·4711, and acres may be expressed in hectares by dividing by 0·40467. In drawing out the equivalents of mixed quantities, it facilitates the calculation to reduce the expression to its lowest term. Thus, to bring 5 acres 3 roods 2 perches to ares, the expression should be reduced to perches and divided by 25·29. The quotient will be square metres or hundredths of an are.

LINEAL MEASUREMENT

1 Millimètre		·039370 English Imperial inches.	1 Inch		25·399 millimetre.
1 Centimètre		·393704	1 Foot	=	30·479 centimètre.
1 Decimètre	=	3·937042	1 Yard	=	·91438 metre.
1 Mètre		3·28086 .. .. feet.	1 Chain	=	20·116 mètres.
1 Toise	=	6·56181	1 Furlong	=	201·164 mètres.
1 Myriamètre or 10 Kilomètres or 100 Hectomètres or 1000 Decamètres	=	6 miles, 1 furlong, 28 poles 2¼ yards or 6·21375 English miles.	1 Mile	–	1609·3149 mètres.

SURFACE MEASUREMENT

1 Milliare or square decimètre	=	·01196 English square yards.	1 Square inch	=	6·451 centimètres carrés. (square centimètres).
1 Centiare or square mètre		1·1196	1 Square foot		9·29 decimètres carrés.
1 Are or square decamètre or 100 centiares	=	·024711 Imperial acre.	1 Square yard		0·836 mètre carré.
1 Hectare or 100 ares	=	2·4711 acres.	1 Perch	=	25·29 mètres carrés.
			1 Rood	=	10·1168 ares.
			1 Acre	=	0·40467 hectare.
			1 Square mile	=	2·5899 kilomètres carrés.

SOLID MEASUREMENT

1 Millistère	=	·0353156 English cubic feet.	1 Cubic inch	=	16·3862 centimètres cubes.
1 Stère or cubic mètre or 10 Decistères or 100 Centistères or 1000 Millistères	=	35·317 English cubic feet.	1 Cubic foot	=	28·3153 decimètres cubes.
			1 Cubic yard	=	0·7645 mètre cube.

The Paris foot = 1·0936 English feet.

Continued

ENGLISH DRAMA SINCE SHAKESPEARE

A Concise Review of the Leading Dramatic Poets and Playwrights in the Seventeenth, Eighteenth, and Nineteenth Centuries

Continued from page [illegible]

By J. A. HAMMERTON

Character of the Restoration Drama. No comparison is possible between the drama of the Elizabethans and that of their immediate successors. It is all contrast—the contrast, one great critic has said, of Hyperion and a Satyr. We shall not go so far as that. We have to remember Mr. George Meredith's eulogy of Congreve. But all the brilliancy of the "comic dramatists of the Restoration" cannot blind us to the fact that when women made their first professional appearance on an English stage, the chief theme of the plays that were written at that time was the ridicule of the marriage state, to the end that the ribald laughter of a dissolute Court might be provoked and the cheap cynicism of "the man of the world" encouraged in its vacuity. It may be mentioned, however, as interesting in this connection, that the first *rôle* professionally rendered by a woman in a public theatre in this country was that of Desdemona in "Othello." Mr. Nichol Smith has been at some pains to show that the eighteenth century rendered tribute where tribute was due, but the playwrights of the latter half of the seventeenth century translated Shakespeare for stage purposes much as Bottom was "translated." Even Dryden is not exempt from the mania for painting the lily in fancy hues.

The why and the wherefore of a study of the Restoration drama are so admirably set forth in one of Macaulay's "Essays"—the review of Leigh Hunt's edition of the Works of Wycherley, Congreve, Vanbrugh, and Farquhar—that we can hardly do better than commend this essay to the reader at the outset.

Dryden and His Contemporaries. Again passing over THOMAS RANDOLPH (b. 1605; d. 1635) as only of exotic interest, the first name that claims our attention is that of SIR WILLIAM DAVENANT (b. 1606; d. 1668). Davenant's work well reflects the spirit of reaction against Puritanism; much of it was unworthy of the man's better parts. His "heroic play" of the "Siege of Rhodes" is the germ of English opera, and he introduced many accessories to the theatre, including the orchestra. THOMAS KILLIGREW (b. 1612; d. 1683) is the author of a comedy, "The Parson's Wedding," which, we are told by Pepys, was originally acted by a female cast. He built a playhouse in 1663 on the site of the present Drury Lane Theatre.

JOHN DRYDEN (b. 1631; d. 1700), at the instance of Davenant, wrote an absurd adaptation of "The Tempest," and a capital blank verse tragedy, "All for Love," on the lines of "Antony and Cleopatra." He adapted the "heroic couplet" to the English drama, thus winning the approval of Charles II. and the ridicule of the Duke of Buckingham in "The Rehearsal." His characters are, in the main, abstractions; he uses noble language to convey ideas full of extravagance. But his tragedies of "Don Sebastian" and "Cleomenes," together with the comedies of "Marriage à la Mode" and "The Spanish Friar," contain much that is eminently readable. Avowedly, he wrote plays not because the work was congenial, nor because he thought of posterity, but to make money. Considering the variety of his literary output in other directions, it is remarkable that his position as a dramatist stands so high as it does. The student should not miss his "Essay on Dramatic Poesy."

SIR GEORGE ETHEREGE (b. about 1635; d. 1691) was one of the first to employ rhyme in comedy. There was little harmony in his character. His plays are pictures of the high life of the period, and altogether unsuitable for general reading. His three comedies, "The Comical Revenge; or, Love in a Tub," "She Would if She Could," and "The Man of Mode; or, Sir Fopling Flutter," may be classed with the plays of TOM D'URFEY (b. 1653; d. 1723), THOMAS SHADWELL (b. 1642; d. 1692), and Mrs. APHRA BEHN (b. 1640; d. 1689). D'Urfey deserves special mention because of his songs and the friendship which both Addison and Steele extended to him.

William Wycherley (b. 1640; d. 1715). Wycherley was one of the two great lights of Restoration comedy. Said Evelyn:

> "As long as men are false and women vain,
> Whilst gold continues to be virtue's bane,
> In pointed satire Wycherley shall reign."

Like Dryden, Wycherley made a rather feeble first effort at writing for the stage. Also like Dryden, but with greater success, he sought and found inspiration in France and Spain. He may be described as the originator of our comedy of manners. "He was a ruffian," says Mr. Gosse, "but a ruffian of genius." "The only thing original about Wycherley," writes Mr. W. C. Ward, "the only thing which he could furnish from his own mind in inexhaustible abundance, was profligacy." He was a faithful mirror of his own time. His chief comedies are "The Plain Dealer" and "The Country Wife." The one is founded on Molière's "Le Misanthrope," and is praised by Hazlitt as "a most severe and poignant moral satire"; the other loses our respect and much of such admiration as its workmanship claims when compared with its sources, Molière's "L'Ecole des Maris" and "L'Ecole des Femmes." Wycherley's own life provides the most effective satire on the social ideals of his period.

William Congreve. In the works of William Congreve (b. 1670; d. 1729) the comedy of manners attains its apogee. "The Old Bachelor," "The Double Dealer," "Love for Love," "The Mourning Bride," and "The Way of the World" were all written before their author was thirty years old. Then came sinecures and literary sterility. Congreve was, and remains, a master of repartee and accomplished insolence. He wrote better than Molière; but Molière's stage method and dramatic style preserve his plays alive while those of Congreve, if we except "Love for Love," which has been described as the finest prose comedy in the English language, are consigned to the study. "In every point," writes Mr. G. C. Ewald, "Congreve maintained his superiority to Wycherley. Wycherley had wit; but the wit of Congreve far outshines that of every comic writer, except Sheridan, who has arisen within the last two centuries. Congreve had not in a large measure the poetical faculty; but, compared with Wycherley, he might be called a great poet. Wycherley had some knowledge of books, but Congreve was a man of real learning. Congreve's offences against decorum, though highly culpable, were not so gross as those of Wycherley, nor did Congreve, like Wycherley, exhibit to the world the deplorable spectacle of a licentious dotage." Thackeray declared that "the Congreve muse is dead, and her song choked in Time's ashes." "See," he exclaimed, "there's the cup she drank from, the gold chain she wore on her neck, the vase which held the rouge for her cheeks, her looking-glass, and the harp she used to dance to! Instead of a feast we find a gravestone, and in place of a mistress a few bones." Some phrases from the Congreve comedies long since passed into the common speech: "Music hath charms to soothe the savage breast," "Heaven has no rage like love to hatred turned, nor hell a fury like a woman scorned," "Married in haste, we may repent at leisure" are among them.

Vanbrugh and Others. What Sir John Vanbrugh (b. 1664; d. 1726) lacked in grace he had in coarse wit and facile inventiveness. The epitaph—

> "Lie heavy on him, earth! for he
> Laid many heavy loads on thee,"

alludes to his achievements as the architect of Blenheim and Castle Howard, not to his authorship of "The Relapse," "The Provoked Wife," and "The Confederacy." With Vanbrugh may be compared George Farquhar (b. 1678; d. 1707), who, in some directions as a dramatist, improved on his predecessors in cogency of construction, and whose incidental verse indicates a power that—possibly for reasons connected with a hand-to-mouth sort of existence—was never fully cultivated. The famous line from his "Twin Rivals"—

> "Necessity, the mother of invention"

—is singularly apposite to its author. Horace Walpole said of Farquhar's plays that they talk the language of a marching regiment in country quarters. He wrote best what he wrote last, "The Recruiting Officer" and "The Beaux' Stratagem." He marks the transition from Restoration licence towards the purer, if more conventional, stage methods belonging to the reign of Queen Anne and the Early Hanoverians.

Thomas Otway. In Thomas Otway (b. 1651; d. 1685), it has been well observed, "there is no relief, no pause from the war and clamour of passion." He lived tragically, wrote tragedy, and died young. Gloomy as are his plays and devoid of lyrical beauty, they reach the heart by sheer force and knowledge of human nature. "More tears," said Sir Walter Scott, "have been shed probably for the sorrows of Belvidera [in "Venice Preserved"] and Monimia [in "The Orphan"] than for those of Juliet and Desdemona." Of "Venice Preserved," which awakened the praise of Dryden, Hazlitt, and Taine, versions have been made in French, German, Dutch, Russian, and Italian. Otway is a strayed tragedian, belonging by genius, if not by time, to the Elizabethans.

The Lesser Dramatists. Other names that can only be given bare mention as those of dramatists of some, but lesser, note are: Nathaniel Lee (b. 1653; d. 1692), who collaborated with Dryden in "Œdipus," and who is best represented by "The Rival Queens"; John Crowne (d. 1703), author of "Thyestes" and "Sir Courtly Nice"; Nahum Tate (b. 1652; d. 1715), whose version of "King Lear," in which Cordelia survives and marries Edgar, held the stage till the middle of the nineteenth century; Colley Cibber (b. 1671; d. 1757), who appears to have been better as a comedian than as a playwright, though his version of Shakespeare's "Richard III." has been frequently performed in the provinces even of recent years; Nicholas Rowe (b. 1674; d. 1718), whose "Jane Shore," is still acted, and who in "The Fair Penitent" (adapted from Massinger's "The Fatal Dowry") drew the prototype of Richardson's Lovelace; Thomas Southerne (b. 1660; d. 1746), whose "The Fatal Marriage" and "Oroonoko," founded on novels by Mrs. Aphra Behn, enjoyed a century's popularity; Elkanah Settle (b. 1648; d. 1724), author of a "heroic" piece of bombast called "The Empress of Morocco"; John Gay (b. 1688; d. 1732), author of "The Beggar's Opera" and the libretto for Handel's "Acis and Galatea"; and Richard Savage (d. 1743), who wrote a comedy, "Love in a Veil," a tragedy, "Sir Thomas Overbury," and inspired Johnson to the writing of one of the best, if by no means the most accurate, of short biographies. Here brief mention must also be made of Joseph Addison (b. 1672; d. 1719) as the author of "Cato," a tragedy which has enjoyed in literature a European reputation; Sir Richard Steele (b. 1672; d. 1729), "the father of sentimental comedy"; Samuel Johnson (b. 1709; d. 1784), as the author of "Irene," a tragedy which all Garrick's zeal could not make successful, and concerning which Boswell has some entertaining pages; Samuel Foote

(b. 1720; d. 1777), a social satirist in Jonson's vein; **DAVID GARRICK** (b. 1717; d. 1779), whose adaptations, together with his prologues and epilogues, are of merit; **GEORGE COLMAN** the elder (b. 1732; d. 1794), who collaborated with Garrick in "The Clandestine Marriage," and wrote "The Jealous Wife"; **GEORGE COLMAN** the younger (b. 1762; d. 1836), author of "The Heir-at-Law," a comedy of sterling qualities; **JOHN HOME** (b. 1722; d. 1808), author of "Douglas"; and **RICHARD CUMBERLAND** (b. 1732; d. 1811), author of "The West Indian." To the comedies of **HENRY FIELDING** (b. 1707; d. 1754), written after the manner of Congreve, may be applied the description given by Jonson of Cardinal de Perron's translation of Vergil—namely, "That they were naught."

WILLIAM WYCHERLEY

WILLIAM CONGREVE

RICHARD BRINSLEY SHERIDAN

THOMAS OTWAY

Goldsmith and Sheridan. **OLIVER GOLDSMITH** (b. 1728; d. 1774) was unlucky in the circumstances attending the production of the first of his two comedies, "The Good-Natured Man." It was poorly acted; but genius prevailed. The lovable qualities found in all he wrote distinguished both "The Good-Natured Man" and "She Stoops to Conquer." These two comedies, the proceeds of which made their author for the time being a man of fortune, have been referred to as the greenest spots in the dramatic history of the period to which they belong, and as containing "wit without licentiousness; humour without extravagance, brilliant and elegant dialogue, and forcible but natural delineation of character." **RICHARD BRINSLEY SHERIDAN** (b. 1751; d. 1816), whose personality and romantic love-story have been made clearer for us by Sir Herbert Maxwell's study of "The Creevey Papers," is as popular on the stage as Shakespeare; to the graceful humour of Goldsmith he added the wit, without the grossness, of Congreve. Of his four comedies, "The Rivals," "The School for Scandal," "The Critic," and "The Duenna," the first and second are the best known. Here is what his contemporary Creevey says: "'The Rivals' upon its first performance was damned. When Sheridan got to Slough [his home], and told his wife of it, she said, 'My dear Dick, I am delighted. I always knew it was impossible you could make anything by writing plays; so now there is nothing for it but my beginning to sing publicly again, and we shall have as much money as we like.' 'No,' said Sheridan, 'that shall never be. I see where the fault was; the play was too long and the parts were badly cast.' So he altered and curtailed the play and had address or interest enough to get the parts newly cast. At the expiration of six weeks it was acted again, and with unbounded applause." Of Sheridan's comic muse Hazlitt says: "She does not go prying about into obscure corners or collecting idle curiosities, but shows her laughing face and points to her rich treasure, the follies of mankind. She is garlanded and crowned with roses and vine-leaves; her eyes sparkle with delight, and her heart runs over with good-natured malice; her step is light, and her ornaments are consummate." Lord Byron wrote on learning of Sheridan's death:

"Long shall we seek his likeness
—long in vain,
And turn to all of him which
may remain,
Sighing that Nature formed but
one such man,
And broke the die—in moulding Sheridan."

The Drama of the Nineteenth Century. When the nineteenth century opened, Shakespeare shared with Goldsmith and Sheridan all the distinctive honours. The other dramatists, in the stage sense of the term, were hard to seek.

"**MONK**" (**MATTHEW GREGORY**) **LEWIS** (b. 1775; d. 1818), of "The Castle Spectre"; **THOMAS HOLCROFT** (b. 1745; d. 1809), author of "The Road to Ruin"; **JAMES SHERIDAN KNOWLES** (b. 1784; d. 1862), who wrote "The

"Hunchback" and "The Love Chase"; **Bryan Waller Procter** (b. 1787; d. 1874), whose tragedy of "Mirandola" is amongst the least of his literary achievements; **Joanna Baillie** (b. 1762; d. 1851) and **Elizabeth Inchbald** (b. 1753; d. 1821) are among the best of the playwriters of the time. **Samuel Taylor Coleridge** (b. 1772; d. 1834) translated Schiller's "Wallenstein," and wrote a five-act tragedy, "Remorse," which, says Mr. Swinburne (paraphrasing Jonson), contains "little worth praise or worth memory, except such casual fragments of noble verse as may readily be detached from the loose and pliable stuff in which they lay embedded." It ran for twenty nights at Drury Lane, in 1813. Another half-forgotten tragedy of the period is that of "Bertram," by the Rev. **Charles Robert Maturin** (b. 1782; d. 1824), which was produced by Kean, at Drury Lane, in 1816, on the recommendation of **Lord Byron** (b. 1788; d. 1824), whose own contributions to literary drama—"Manfred," "Marino Faliero," "Sardanapalus," "The Two Foscari," "Cain," "Heaven and Earth," "Werner," and "The Deformed Transformed"—will be dealt with in connection with his poetry, as will "The Bride's Tragedy" of **Thomas Lovell Beddoes** (b. 1803; d. 1849); and "The Cenci," by **Percy Bysshe Shelley** (b. 1792; d. 1822). Byron's plays found their way to the stage for other reasons than their intrinsic value for acting purposes. "Ion," a Greek tragedy by Sir **Thomas Noon Talfourd** (b. 1795; d. 1854), and "Philip van Artevelde," by Sir **Henry Taylor** (b. 1800; d. 1886), are both works for the reader rather than for the playgoer. "Philip van Artevelde" is a romance that has received far too little attention. One of the most popular of the dramatists of the nineteenth century was **Edward Bulwer, Lord Lytton** (b. 1803; d. 1873), whose plays, "The Lady of Lyons," "Money," and "Richelieu," for all their artificialities of sentiment, still retain a strong hold upon the public. This is also the case with such plays as "Society," "Caste," and "Ours," by **Thomas William Robertson** (b. 1829; d. 1871); "Masks and Faces" and "It is Never too Late to Mend," by **Charles Reade** (b. 1814; d. 1884); "Still Waters Run Deep," by **Tom Taylor** (b. 1817; d. 1880); "Black-Eyed Susan," by **Douglas Jerrold** (b. 1803; d. 1857); "London Assurance" and "Colleen Bawn," by **Dion Boucicault** (b. 1822; d. 1890); and "The Two Roses," by **James Albery** (b. 1838; d. 1889). Comedy lightened into burlesque and extravaganza on the one hand, the work of **Planché**, the brothers **Brough**, **Henry James Byron**, and others; and on the other, into sparkling operas, of which those composed by Sir **Arthur Sullivan** (b. 1842; d. 1900) and **William Schwenck Gilbert** (b. 1836) are incomparably the best.

While comedy was degenerating, the purely literary drama was receiving some noteworthy additions in "Strafford," "A Blot on the 'Scutcheon," "The Return of the Druses," and "Luria," by **Robert Browning** (b. 1812; d. 1889); the "Queen Mary," "Harold," "Becket," and "The Foresters" of **Alfred Tennyson** (b. 1809; d. 1892); and "The Queen Mother," "Rosamond," "Atalanta in Calydon," "Chastelard," "Bothwell," "Mary Stuart," "Erechtheus," "Marino Faliero," "The Sisters," "The Tale of Balen," and "Rosamund, Queen of the Lombards" of **Algernon Charles Swinburne** (b. 1837); the "Demeter" and other plays of **Robert Bridges** (b. 1844); the "Scaramouch in Naxos" and a notable version of Coppée's "Pour la Couronne" of Mr. **John Davidson** (b. 1857); and the "Cosmo de' Medici" and "The Death of Marlowe" of **Richard Henry Horne** (b. 1803; d. 1884). At the present time, where the English drama is not a reflection of Continental authorship, it is indebted to two working playwrights in particular, Mr. **Arthur Wing Pinero** (b. 1855), author of plays as dissimilar as "Sweet Lavender" and "Letty"; and **Henry Arthur Jones** (b. 1851), author of "The Silver King" and "The Liars." The plays of these two dramatists do not indicate a very high tone in the society which they depict. With the drama of Mr. **George Bernard Shaw** (b. 1856) the young student need not be greatly concerned. Quite distinct is the work of Mr. **Stephen Phillips**, whose "Herod" marked the close of the century with a note which awakened aspirations after better things.

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Continued

PRIZES IN SCIENCE & COMMERCE

Continued from page 967

Commercial Aspect of Research and Heroism. The Cultivation of Rubber, Tea and Tobacco. Future of Pasture-farming. Science in the Bakehouse and Machine-shop

By ERNEST A. BRYANT

IF we could have a tabulated list of the callings from which men and women have realised wealth, the result would be surprising. We should miss the names of some of the greatest men in the history of science; the names of many who have added new territories to the map of civilisation; of men whose discoveries in medicine and surgery and in philosophical research are inscribed in imperishable characters in the story of human progress.

The Roll-call of the Wealthy. The man who conquers plague and pestilence may not be of the company; but the man who devises an instrument for the wholesale destruction of life will be there. We may look in vain for the names of Milton and Bunyan, Defoe and Goldsmith, Johnson and Lamb, for Haydon and Lawrence and Watts, but we shall find the names of men who have contributed to the commonplaces of life. It is sadly inevitable that among our grandest figures who have put forth great, heroic effort for the good and betterment of humanity, there must be those who, poor and sad, have only at the last to beg that they may lie, as Browning makes Paracelsus plead to lie,

"Within some narrow grave,
Not by itself—for that would be too proud—
But where such graves are thickest."

Happily, in our list we should have also our heroes who had won reward, as the world views reward—reward in material gain. That man who by his discoveries and inventions increases the common store of wealth and happiness is as much a hero as the man who successfully commands an army and comes to Parliament to be ennobled and endowed with wealth. Still more a hero is he who rises early and takes rest late to devote his life to problems whose solution shall render his fellows more and more immune from the ills to which flesh is heir. The history of the laboratory thrills with the stories of health sacrificed—aye, of lives innumerable given by these self-denying sons of science. It is good and encouraging to find even these unselfish ones represented by a few in the catalogue of the fortunate. Dr. Roux is awarded the Osiris prize of £5,000 for his scientific labours in bacteriology, more particularly in regard to his successful work with the anti-toxin for diphtheria. A new explosive, or a new quick-firing gun would have brought him twenty times as much; but there is encouragement in the prize. Harvey was not one penny the richer for making the greatest discovery in the history of physiology—the discovery of the circulation of the blood.

Facilities for Scientific Research. The modern tendency is to assist with liberal hand the man engaged in work of such importance to the world. Wealthy corporations, established for quite different purposes, now make pecuniary grants, and funds and associations exist solely for the encouragement of scientific research. It is not unreasonable to hope that the day has finally passed for the scientist to be compelled to spend his laborious days in penury.

A War for Humanity's Sake. There is so much for him still to do. Every outbreak of influenza means the sacrifice of more lives than would result from cholera, plague, or war. We track the malaria-carrying mosquito to his breeding ground in the swamps and marshes, the puddles and mud-holes of ill-paved towns. Having tracked him, we are able to exterminate him. Science traces the birth of influenza to a not dissimilar origin—to water stagnating within the cracks in the earth's surface caused by long preceding drought. Within the rifts thus opened is some mysterious poison which is liberated when the sun dries up the water by which it has been absorbed. So far science has taken us; but it has not been able to step in at the fountain head of the mischief and say, once and for all, that then and there the merciless affliction shall cease. No; influenza once started on its fell career sweeps the whole world—north, south, east, and west. Within the memory of almost the youngest who read this paper it has robbed two thrones of their heirs—the thrones respectively of Great Britain and Belgium. We know how to deal with the effects, though the terrible death-roll from an influenza epidemic shows that we cannot be certain of success in any single case. We certainly do not know how to deal with the cause. Wealth and the gratitude of the whole world await the man who can give us immunity from this deadly enemy of the race.

What Science Has to Find. Consider next a smaller subject, but one of great importance to England. In spite of all that our great chemists have been able to perform in synthetic chemistry, they have been utterly baffled, so far, in their attempts to find a substitute for lead in the glazing of pottery. This, perhaps, may not seem to possess any special significance for the man or woman who buys the goods. But the question is one of life and death to those engaged in producing the ware. Lead-poisoning is the great enemy of those who glaze the pottery of commerce. A Royal Commission inquired into the subject a year or two ago, and presented a carefully considered report. The result was discouraging. No one can, as yet, devise a substitute for the lead compounds necessary to the process of manufacture. Either the use of the lead must continue, or the industry must be ruined. If English potters do not manufacture this class of ware with lead as a constituent, foreign firms will. Here, then, is a field for the chemist of to-morrow. Manufacturers would welcome and richly reward the man who could give them the requisite formula to take the place of the health-destroying lead, and the many toilers who now jeopardise their lives by the present methods would heap blessings upon the head of their saviour.

Improving on Nature. Having resolved into its original elements the particular material upon which his attention is fixed, the synthetic chemist can, as a rule, build up in his own laboratory an excellent imitation of the original. By a slight re-grouping of the elements he can largely change the character of the result. Between what he can do in the matter of a substitute for this lead-glaze and the exact compound he actually wants there may be but a little link missing. So long, however, as that one link is lacking, so long is the whole incomplete. A similar result is found in other fields. One of the greatest of new industries is to be the scientific cultivation of rubber. Until comparatively recently, we left the provision of this substance entirely to Nature. It was very dear; the supply was not of dependable uniform quality; but merchants had to bear with it as it was, though declaring themselves ready and willing to pay fifteen per cent. more all round if they could but rely upon rubber of level excellence.

Here, then, obviously, was the opportunity of the synthetist. He makes indigo and a thousand other things for which hitherto we have had to go to Nature; why not rubber? There was a curious difficulty. As every schoolboy knows, the rubber is drawn in fluid form from the tree. It might seem that if we can bring peaches and grapes from the other side of the world without so much as disturbing their bloom, it ought not to be impossible safely and securely to transport this sticky mass. But again and again the attempt to get it over to Europe was baffled. The composition changes when the latex has been drawn from the tree, and upon arrival here is quite different from the fluid which the native artificially coagulated in the depths of the African forest. As the rubber would not come to us, we have had to send men to the rubber to investigate it where it grows. This has been done, and operations to this end are still being carried out with exemplary thoroughness.

A Too Costly Success. Can we now produce rubber artificially? The answer is in the affirmative, but with a qualification. Carl Otto Weber, whose recent death is a great loss to the rubber industry, on which he was the foremost authority, did take it to pieces, as it were, and build up an artificial rubber. Possibly it was as good as the average original, but no purpose was served: the copy was more costly than the natural product. What the young chemist has to do is to follow up the investigations of Weber and perfect a system for a cheap supply of the artificial article

Meanwhile, those who feel that their future lies abroad may with profit study the question of rubber cultivation. The demand for rubber is so enormous that it can no longer be left to haphazard supply. In South America and other places, particularly in Ceylon, the cultivation of the rubber-tree is becoming a fine art. Tea supplanted coffee in Ceylon; now rubber is challenging tea. Here it grows to perfection, and careful husbandry yields handsome profits to the grower. Whereas a few years ago the quantity required for England was measured by hundredweights, now the figures run into many thousands of tons each year. Thousands of patents exist for articles made or fitted with rubber. To the physician and surgeon it is indispensable; it is the only substance in the world which makes a permanently silent roadway; it is the only thing which makes riding possible by bicycle, motor, or cab; and, to go still further, it is the one substance upon which depends a firm from whom are due a million and a quarter tobacco pouches every year. Yet, in spite of all the trade in this rubber, extensive scientific culture is still relatively a new thing. The man who finds a new tract of rubber-trees in Bolivia claims it like a gold-mine. This is an industry well worth the study of the man who listens to the call of distant lands.

Supplying the World's Teapot. Tea-planting is another such industry. Men who visited India and Ceylon years ago, and remember the methods of drying by hand and the clumsy manipulation of the whole process of old days, are amazed now upon revisiting the country to witness the improvements and economies effected by the introduction of machinery. They see, moreover, that finality of improvement has not by any means been reached. Tea-growing is a subject in which Britons, of all men, should be interested. The United Kingdom consumes each year more tea than all the rest of Europe and the United States combined, the total reaching no less vast an amount than 256,000,000 lb. for a single year, representing over 6 lb. of tea per head of population. With so huge a quantity consumed, we ought consistently to follow out the argument that there is no waste in chemistry, and be able to show that the spent leaves of the tea are turned to some account. That may, perhaps, be of the future. It is more easy to distribute tea than to collect the leaves.

The same principle applies to tobacco. The finest manure for this plant is tobacco ash, which simply restores to the earth the mineral properties of which it has been exhausted by producing the tobacco. Acute cultivators have noted an interesting little sum in reciprocity in this connection. Four pounds of tobacco yield one pound of ash; one pound of ash, placed as manure upon the land, serves for four more pounds of tobacco. Two million acres of the earth's surface are under tobacco cultivation, and that area is capable of infinite extension, for tobacco will grow in any climate, though, of course, the tropics are most favourable to the best crops, as is the case with rubber. From both plants the seeds are carefully collected, which, in the latter case, is a modern departure

The Future of the Pasture. This leads to another consideration, bringing us home to the pastures of the homeland. It would be hard to-day to convince the farmer that motor traffic will ever seriously compete with the horse which he so well loves. It was not less difficult to persuade our fathers that the locomotive engine would drive the great lumbering coaches off the roads. Trains might run, they agreed, but they would never be drawn about the country by engines; they would be "wound" along the lines by pulleys and ropes from point to point, after the fashion which men still living remember to have seen on London railways. But the locomotive did come, and did conquer; and the motor has come, and in turn is conquering. Therefore, horses, while they will never disappear from all classes of work, must in course of time greatly diminish in numbers. That is serious for the horse breeder. It is still more threatening to a larger industry—to agriculture.

Who shall find a market for hay and straw when the motor replaces the horse? Even now, with many horses to feed, there is, in the case of a favourable summer, an excess of clover hay in the country. What is to happen when fewer horses require fodder? The last man whom the average farmer would think of consulting is he to whom he will have eventually to turn—the chemist.

Not everything is possible to the chemist. Certain economic difficulties remain insuperable even to the scientist The conversion of the balance of hay and straw into commercial commodities would not be chemically impossible. The difficulty which does baffle him, however, is that of cost. No matter how ingenious his methods, the chemist cannot command success for uncommercial enterprises. Straw and hay may be of the best quality, and comprehensive of virtues innumerable, but the price charged for transporting it from the farm to the town, and of storing it there, is so excessive as to make manufacturers' ventures with these products as constituents highly unlikely. Other means must, then, be sought.

The Chemist to the Rescue. He will have to discover new methods of combining the surplus hay with other substances as a food for fattening stock. Instead of growing clover for horses, farmers will grow it for cattle. Whatever he may do with ourselves, the chemist will never feed sheep and bullocks on a tabloid diet. There must be bulk as well as nutriment for stock. Hence the cattle must have their good, weighty fodder, and the farmer will have to grow it for them. The disappearance of the horse, then, viewed from this standpoint, will not be of serious moment. The net result will be to benefit the agriculturist. With new means devised for feeding cattle, with British crops as an essential basis, money will be kept in the country which now goes abroad for feeding-stuffs—for which we pay yearly an enormous sum. The outcome will be to place more stock upon our pastures, and out of threatened evil good will come.

With foodstuffs in mind, it is not inopportune to refer to an article of a different character. At the present moment England stands pre-eminent for her biscuits. No other country can even distantly approach her, nor, with hope of success, enter her markets. She supplies the biscuits of practically the whole world, and has done so ever since biscuits first were. But here is a trade which has found it necessary, in spite of its strong position, to keep abreast of the times. For every variety of biscuit which the confectioner sold a dozen years ago, there are now a score. One of the most popular of the innovations is the flavoured biscuit. This is the line along which the development of the future has to come. Excellent as have been the results already attained, better are being sought, and there is still room for improvement.

Science in the Bakehouse. According to a very eminent authority the biscuit-making trade—taken not, of course, with reference to any one branch, but as a whole—does not so thoroughly appreciate the value of essences and flavourings as it might do. With the makers of essences and superior soap the study of essences, with all their blendings and other possibilities, is a fine art. The biscuit-maker needs a laboratory and a chemist. Perhaps some factories are already equipped in this manner; if so, they need not fear an extension of the principle. For there is rivalry to come. Seeing that England has so long led in the manufacture of biscuits, naturally her machinery is the best at present made. She is not longer to retain unchallenged the possession of such advantages. At the present time, in America and elsewhere, manufacturers are setting up British machinery for the purpose of competing with the Old Country. This machinery has to pay a duty of 45 per cent. on entering the United States, whereas, of course, machinery built there by American firms pays nothing. In spite of that, however, the English makers are kept busily employed in laying down plants for our future rivals.

English Experts for America. As they get the machinery, the Americans ask for men. "Send us experts to operate these plants," they are saying. Where are the experts? England has not one to spare; she needs more for her own works. The man who is qualified from the chemical standpoint and from—for lack of a better term—the cooking standpoint, is an exception. Very properly, British firms keep their trade secrets, and no man is at liberty to dispose of them. The trade, however, will have to be studied from a different standpoint. England cannot compare at present with the Continent in the matter of expert knowledge of essences and flavourings, so that while she has the best of practical biscuit-makers, she has to fear the expert theorist who will impart his knowledge to the practical baker.

Every student of industries must have observed to what a remarkable extent trades nationalise or localise themselves. A hundred different trades have as many distinct areas in London. In the provinces you find cotton in Lancashire, wool in Yorkshire, boots in Northamptonshire, lace in Nottinghamshire, straw-plaiting in Bedfordshire, hosiery in Leicestershire, and so on. The constant effort of nations, as of local authorities, is to introduce and foster new industries. Japan, during the last forty years, has made herself a great industrial, as well as warlike, power solely by this means. Every modern art she possesses she has acquired by copying from the West—by sending students abroad, by getting Englishmen and Germans, and American and Frenchmen there. We in this country profited by unsought advantages of a like kind long ago.

Our Beneficent Invasions. St. Bartholomew's Eve helped almost incredibly to make us the first commercial nation of the world. The Huguenot refugees, fleeing to England for asylum and refuge from the bloody tyrant by whom their deaths had been decreed, brought with them the peaceful arts of which they were masters. And that which they knew they taught in England. They brought with them and established here the woollen, worsted, and napery industries, silk-weaving, tapestry, dyeing, glass-making, pottery, and paper-making; they gave us men of light and leading for the Church, statecraft, and the Law, gallant men and skilled for the Army and Navy, artists, poets, men of letters. The peaceful invasions to which now and again we are subjected assume a different form.

We, like Japan, have again and again to Westernise. The Americans cause us to remodel our methods of making boots and matches We have to be content with typewriters of their make, with their calculating machines, their electrical inventions, their dictionaries, and, very largely, their furniture. We are about to model our building methods upon theirs. If we do not, they will do the building for us, as indeed they have done in more than one instance already—notably at Manchester, and in the electrification of the London District Railway. If only another Yerkes would come to take in hand the Port of London, the metropolis might hope. The spirited manner in which these industrial invasions are met and countered—for Englishmen of dash and genius carry the war into the heart of the enemy's camp at times—shows that Britons have not lost their old adaptability, their power easily and rapidly to conform to new demands and new conditions. The old theory that once a nation is mistress of a certain industry she shall for ever remain mistress of that industry is breaking down. Increased competition by rivals, who but the other day were inconsiderable, has taught England a lesson by which she has not been slow to profit.

The New Spirit. The need for this modernising of method was expressed by King Edward, as Prince of Wales, in a notable speech delivered in London some years ago: "Hitherto English teaching has relied chiefly on training the intellectual faculties, so as to adapt men to apply their intelligence in any occupation of life to which they may be called. And this general discipline of the mind has, on the whole, been found sufficient until recent times; but during the last thirty years the competition of other nations, even in manufactures which were once exclusively carried on in this kingdom, has been very severe. The great progress that has been made in the means of locomotion, as well as in the application of steam for the purposes of life, has distributed the raw materials of industry all over the world, and has economised time and labour in their conversion to objects of utility. Other nations which did not possess in such abundance as Great Britain coal—the source of power—and iron—the essence of strength—compensated for the want of raw material by the technical education of their classes, and this country has, therefore, seen manufactures springing up everywhere, guided by the trained intelligence thus created. Both in Europe and America technical colleges for teaching, not the practice, but the principles of science and art involved in particular industries have been organised in all the leading centres of industry. England is now thoroughly aware of the necessity for supplementing her educational institutions by colleges of a like nature. Most of our great manufacturing towns have either started or have already erected their colleges of science and art. In only a few instances, however, have they become developed into schools for systematic instruction."

National effort has yet to be regarded as essential. Hitherto personal initiative has been mainly the factor. The success of personal effort makes us hopeful for the issue of schemes founded upon a broader base. The result of the work of men of modern ideas in specific industries may be traced in many directions.

Revolutions in Industry. What business man could afford to dispense nowadays with a roller-top desk? That is, supposing he has ever used one. All those desks came originally from America. The idea was not new. In the homes of many of us there are old-fashioned bureaux with the flexible lattice top. It was the application of the idea which was new. That was American. It required special machinery; that, too, was American. For some time the Americans completely dominated our market for these desks and similar furniture for the office and the library and study. English cabinet-makers have taken the lesson to heart, and to-day, by the aid of new and excellent machinery, are sweeping the American manufacturer out of the market. New machinery has been laid down in many of our great boot manufactories, and the result again is the extinction of American goods. The English manufacturer has only to give his mind to the accomplishment of reform; the result is assured. The best English work is still incomparable. We shall later on, trace other important industries in which similar revolutions are in progress, and point finally to directions yet open to men with initiative and industry.

Continued

CARBON & ALLIED ELEMENTS

Its Forms and Simpler Compounds. The Allies of Carbon : Silicon, Tin, Lead. Nitrogen and its Related Elements : Phosphorus, Arsenic, Antimony, Bismuth

Group 5
CHEMISTRY
8

Continued from page 1048

By Dr. C. W. SALEEBY

Diamond. The diamond is almost absolutely pure carbon. Its nature was proved by the celebrated French chemist Lavoisier, who succeeded in burning diamonds, and proving that the sole product of their combustion was carbonic acid (CO_2). We know now also that if the diamond be raised to a white heat in the absence of oxygen, it swells up, and is transformed into a black mass, which is practically a shapeless lump of charcoal. Diamonds which are not perfectly white owe their colour to the presence of oxides of various metals, such as iron. Diamond is the hardest substance known. It occurs in many crystalline forms, but they are all derived from the cube. The property which gives it its peculiar beauty is its very high power of refracting light—that is to say, bending rays of light, and, incidentally, breaking them up. [See Optics, in the course of PHYSICS.] Diamonds are most abundantly found at the Cape and in Brazil, but formerly they were only known in the Deccan in India. The hardness of the diamond gives it a practical use as an instrument for cutting glass and for drilling rocks. The value of diamonds is variously stated to increase as the square or as the cube of their weight.

Graphite. Graphite is the second allotropic form of carbon which we have to consider. It occurs in Cornwall and Cumberland, in the United States, and elsewhere. The carbon which separates out from cast iron when it is slowly cooled is graphite. It crystallises in the form of six-sided plates. Apparently in order to confuse the student, graphite is known by two names which attempt to persuade him that it consists of lead. These are *blacklead* and *plumbago*. Besides its use in making pencils and blacking grates, graphite is also employed for the making of moulds for iron casting, and is also mixed with fireclay for the making of crucibles.

Charcoal. Charcoal is an amorphous form of carbon, and is obtained from two distinct sources. *Animal charcoal* is obtained from bones by heating them in the absence of air, and is thus also known as bone-black or bone-charcoal. It, however, is an exceedingly impure form of carbon, a very large part of it consisting of phosphate of lime. It has a peculiar affinity for colouring matters, and is used in the process of refining sugar so as to remove colouring matter from it. It is also an ingredient of blacking, and is employed as a pigment. Lampblack is another impure form of carbon, which is obtained by the imperfect combustion of oil, and is also used as a pigment.

Wood Charcoal. This is made by charring wood. It is far from pure, but contains a much larger proportion of carbon than does animal charcoal. The time-honoured way of preparing it is by piling the wood in a heap, covering it over with turf, and then setting it on fire. The result is a number of lumps of wood charcoal which retain the original shape of the pieces of wood. It is an ingredient of old-fashioned gunpowder, mixed with sulphur and nitre or saltpetre, the nitrate of potassium. This form of carbon has a peculiar physical property ; it is extremely porous, and thus will hold a large quantity of gas ; but more than that, it has a power, hitherto unexplained, of condensing gases on its surface and in its substance. A given quantity of wood charcoal will absorb or occlude an amount of gas which would otherwise occupy hundreds of times its own volume. Wood charcoal is thus a deodorant, having the power of removing bad smells ; but it is also in some measure a disinfectant, for it accumulates oxygen in its pores in a highly condensed and therefore very active form, by which means it is enabled, so to speak, to burn up microbes and bring their life to an end.

Gas Carbon. Another variety is gas carbon—porous, greyish black, and exceedingly hard—which is deposited in gas retorts during the process of making gas from coal. The coal gas consists largely of compounds of hydrogen and carbon, and it is from these that gas carbon is obtained. It also is amorphous.

Coal. Coal is one of the most important forms of carbon, of which it contains from about 70 per cent. in the poorest forms of coal up to 97 per cent. in anthracite. Anthracite coal is a direct product of the activity of chlorophyll, the substance which we mentioned in the last section. It consists of the carbon remains of certain forms of giant ferns which flourished upon large portions of the earth's surface many geological ages ago. Coal is the characteristic constituent of the geological stratum which is known as the carboniferous. [See GEOLOGY.] There is good scientific ground for the poetical description of coal as " buried sunshine " ; for the activity of the chlorophyll, to which it owes its formation, depends entirely upon the action of sunlight. When coal is heated in the absence of air, as for instance in the manufacture of coal gas, we obtain not only the gas carbon which is deposited on the upper surfaces of the gas retorts, but also the product which we call coke. This by no means consists of pure carbon, but it is very much purer than coal.

The briefest reference may be made to some very interesting experiments by Sir James Dewar upon the behaviour of the various forms of carbon at extremely low temperatures, especially in relation to their power, already referred to, of occluding gases. He finds that when charcoal, for instance, is immersed in liquid air, its power of gaseous absorption is extraordinarily increased. We have yet to reach the explanation of these, and countless other facts, which belong to the new science of physical chemistry.

Oxides of Carbon. Carbon forms two compounds with oxygen, both of which are of great importance. The simplest is known as *carbon monoxide*, or *carbonic oxide*, and has the formula CO. It is an odourless, tasteless, colourless gas, and is produced in nature when carbon is burnt with an amount of oxygen which does not suffice for its complete oxidation. For, when carbon is completely oxidised, there is produced the substance known as carbon dioxide, or carbonic acid, which has the formula CO_2. Carbonic oxide may also be formed by reduction of carbon dioxide by means of red-hot carbon, according to the equation

$$CO_2 + C \quad 2CO.$$

This process may be observed in a hot fire, and is of importance, because it occurs in coke stoves. In an ordinary fire, the coal which is near the front, and thus receives abundance of oxygen, undergoes complete combustion, and yields carbon dioxide; but as this gas passes backwards over the red-hot coal at the back of the fire it is reduced, according to the above equation, and yields carbon monoxide; but as this arises it meets with a better supply of oxygen, and is itself burnt to form carbon dioxide again. It burns with a blue flame, which may be constantly seen in a very hot fire or a charcoal stove. The formation of carbon monoxide in this fashion is a very frequent cause of death abroad, where charcoal is frequently burnt in rooms insufficiently ventilated.

Now, why is this gas poisonous? We are able to answer the question very precisely. Carbonic oxide is poisonous in a special sense, as carbon dioxide is not, because it is capable of combining with the hæmoglobin of the blood, which was mentioned in our discussion of iron. Carbonic oxide forms a very firm union with hæmoglobin, yielding a compound which has a very bright red colour, and gives a characteristic tint, which has been described as cherry-red, to the blood of persons poisoned by this gas. This compound is a very firm one, and it prevents the hæmoglobin of the blood thus occupied from performing its proper function of carrying the oxygen of the air from the lungs to the tissues. Thus the patient dies of a kind of suffocation. The especial danger of this gas is that its accumulation in a room offers no warning to the senses of smell or taste.

Carbonic Acid. We may as well at once admit that this is not really an accurate name for what should more properly be called carbon dioxide (CO_2). A more accurate name, often employed, but unfortunately calculated further to puzzle the student, is *carbonic anhydride*. The meaning of this last word must be explained. An anhydride (which really means *not water*) is an acid from which have been removed the elements which correspond to the constitution of water—that is, in the proportion of two atoms of hydrogen to one of oxygen. The name carbonic acid should properly be confined to the union of carbon dioxide and water. If we combine the two formulas, H_2O and CO_2, and write the product with the hydrogen first—as we usually write the name of an acid—we get the formula H_2CO_3, and it is this substance to which the name of carbonic acid should properly be confined. This substance is not a mere chemical fiction; it has a real existence, though it is very unstable. If carbon dioxide be dissolved in water, we find that this substance is present. In the first place, such water has a very faintly acid taste—the taste of soda-water; in the second place, it is like an acid in its action on litmus paper.

Litmus. Litmus is a vegetable substance which is prepared from certain lichens, and acts as an extremely delicate test for the presence of acids and alkalies. A solution of it in water, carefully prepared so that not a trace of free alkali or free acid is present, has a violet colour, and blotting-paper may be impregnated with it. If, now, such litmus paper, as it is called, be exposed to the faintest trace of free acid, it immediately turns red, but if to the faintest trace of free alkali, it immediately turns blue.

Carbon Dioxide. We are entitled to conclude, then, that the solution of carbon dioxide in water is more than a mere solution, and includes a true acid H_2CO_3, to which, if we were to be strict, we should have to confine the name of carbonic acid; but as soon as the water is heated the acid is broken up and carbon dioxide, or carbonic anhydride—we now see the reason for the name—is given off.

This most important substance is a colourless gas, all but free from smell and taste, and is normally produced by the complete oxidation of carbon. This is true, whether the carbon be coal in the fireplace, or carbon combined in living tissues. Every living thing, from microbes up to man, incessantly produces carbon dioxide as the consequence of its life. The gas is also produced as the result of the decomposition of dead organic matter. It is found in coal-mines also, and as it will not support life constitutes a source of great danger to the miner, who calls it *choke-damp*. It is also produced in mines as the result of explosions of another gas called *fire-damp*, and then the coal-miner calls it *after-damp*. This is responsible for the loss of many lives. The gas is heavier than air, and thus accumulates in the lowest parts of coal-mines, old wells, and the like. The most convenient test for ascertaining whether it is safe to descend a well, for instance, consists in lowering a lighted candle and seeing whether it will continue to burn. It will, of course, be at once extinguished if plunged into an atmosphere of carbon dioxide. Upon the weight of carbon dioxide depends the singularly brutal form of scientific experiment which is performed, or used to be performed, at the Grotto del Cane, in Italy, where a layer of carbonic acid lies upon the floor of the cave. Thus, human beings can walk in with impunity, but dogs which are completely immersed in the carbonic acid promptly succumb. Hence the name of the place.

Carbon dioxide is produced when we heat or otherwise decompose a carbonate. This was the famous experiment of Joseph Black, whom we mentioned in our initial chapter. He heated chalk, which we now know to consist of calcium carbonate, or carbonate of lime ($CaCO_3$), and showed that it was converted into quicklime whilst losing an "air" which had formerly been "fixed" in it. This he therefore called "fixed air." We now know that it is carbon dioxide, and we are able to write the simple equation which represents the decomposition:

$$CaCO_3 = CaO + CO_2$$

Precisely the same thing happens when a carbonate, such as carbonate of soda, is treated with a strong acid. The acid takes to itself the base of the carbonate, which in this case is sodium, and turns out carbonic acid, which immediately shows itself in the form of bubbles of gas.

Carbonic Acid and the Air. Carbonic acid occurs as a constant constituent of the atmosphere, to the extent of about ·04–·06 per cent. This latter quantity is regarded by hygienists as about the limit which should be set to the amount of this gas permitted to occur in inhabited air; at any rate, the "physiological amount," as it may be called, should barely exceed ·06 per cent. The presence of green plants is important in modifying the percentage of carbon dioxide in air. Flowers and plants are beneficial in a room in daylight, for they reduce the amount of carbonic acid in the air by means of the process which was briefly mentioned when we were discussing iron and chlorophyll; but at night they are powerless. Day and night, like every other living thing, plants breathe, taking in oxygen, giving out carbonic acid, and thus tending to vitiate the air. Under the influence of sunlight this familiar process is more than neutralised, so far as we are concerned, by the converse process, but at night the plant continues to breathe and consume the air, whereas its salutary function ceased at sundown. Therefore remove all plants and flowers from a bed-room at night. The simultaneous performance of two exactly opposite functions in the daytime is perhaps rather confusing. At any rate, our case is simple enough. Day and night we simply add to the carbonic acid in the air, nor can we regain the valuable carbon squandered thereto, except through the mediation of the plant.

Supposed Accumulation of Carbonic Acid. Now, if we picture the entire surface of the earth, on which man is so rapidly increasing, and if we consider that every living thing is incessantly producing carbonic acid during its life, whilst the same gas is evolved from its remains after its death, it may seem probable that at length all the oxygen of the air will be used up and replaced by carbonic acid. The reverse action performed by the green plant in daylight could delay this accumulation, but could not arrest it. Thus the imagination has pictured the last survivor of the human race as gasping for air somewhere on the side of Mount Everest; while his fellow beings, both animal and vegetable, lay drowned beneath him in the rising sea of carbonic acid. But there has now been discovered a compensatory process. We have reason to believe that the percentage of carbonic acid in the air is practically constant everywhere, and at all times. This is a very fortunate circumstance, for our breathing entirely depends for its success upon the presence of a proper percentage of oxygen and a small enough percentage of carbonic acid in the respired air.

The Sea to the Rescue. There is every reason to believe that it is the sea which controls and keeps constant the amount of carbonic acid in the air. Sea-water contains a varying proportion of the carbonate and the bicarbonate of magnesium, the latter salt containing twice as much carbonic acid as the former. Now, the proportion of carbonate to biarbonate varies with the percentage of carbonic acid in the air above the sea. When that percentage tends to rise, what is called the *partial pressure** of the carbonic acid in the air also tends to rise, and the result of raising this pressure is to drive the excess of carbonic acid into the carbonate of magnesium in the sea-water, turning it into bicarbonate. If, on the contrary, there be, let us say, a large forest near the sea, which tends to reduce the amount of carbonic acid in the air and so to lower its partial pressure, some of the bicarbonate of magnesium in the sea-water is decomposed into carbonate and carbonic acid, which latter is given back to the air, the balance being thus restored. Thus, in accordance with the laws of what modern physical chemistry calls *dissociation*, there is an automatic arrangement for regulating and keeping constant the amount of atmospheric carbonic acid. The fact that the percentage of carbonic acid is so constant in different places is easily explained by the incessant movements of the atmosphere. The percentage of this gas in the air of a great town certainly rises during the day, but when the fires go out the wind is soon able to restore the original state of things. This is one of the reasons why night air, despite the popular prejudice against it, is healthier than day air.

Solid Carbonic Acid. We have heard much lately about liquid air and even liquid hydrogen. We also know that Sir James Dewar has succeeded in even solidifying both air and hydrogen. The first gas to be solidified by the chemist was carbonic acid; by the application of sufficient cold and pressure, it may be readily obtained as a substance which has all the appearances of snow. It is not too cold to be held for a short time in the hand.

* See "Atmospheric Pressure" in PHYSICS.

Elements Allied to Carbon. The list of elements which have certain resemblances to carbon includes *silicon*, *tin*, *lead*, all of considerable importance, and three rare elements, *titanium, zirconium, and thorium, only the last of which is of any practical importance. It is the essential constituent of gas-mantles for incandescent lighting. Silicon,* as we have already seen, is exceedingly abundant, but it is never found in the free state in Nature. It may be extracted from its double fluoride with potassium by means of metallic sodium, and then is obtained as a brown powder. But it may also be obtained in black six-sided plates, and therefore presents us with another illustration of allotropy. It is obtained in its crystalline form by dissolving the amorphous powder in molten zinc, and then allowing the solution to cool. Mention has already been made of the resemblances between this substance and carbon, the former the most important element in the organic, and the latter the most important element in the inorganic world. One atom of silicon combines with two of oxygen to form the very abundant compound *silica*, which has the formula SiO_2. Like carbon, silicon combines with hydrogen to form a gaseous compound, and many of the carbon compounds can be paralleled by similar compounds, which differ only in containing carbon instead of silicon. Just as we have carbonates, the foundation of which is CO_2, so there are silicates, the basis of which is SiO_2. Glass consists entirely of silicates, the nature of the base varying in different kinds of glass. Flint glass, for instance, consists of alkaline and lead silicates, while other bases, such as sodium, potassium and calcium, enter into the composition of other kinds of glass. The silicate of sodium, which has the formula Na_2SiO_3—compare the carbonate of sodium Na_2CO_3—goes by the name of water-glass, and is used in solution for the purpose of making wood and other substances fireproof. For a full discussion of the important substance *glass* the reader is referred to the special section dealing with that subject.

Tin. Tin occurs in Nature in the form of its oxide, which is called *tinstone* and has the formula SnO_2. It occurs in Cornwall, as the ancients seem to have known, and also in Australia and Mexico. [See METALLURGY.] Tin forms two series of salts, the stannous and the stannic, the meaning of which terminations was explained in our consideration of iron. The stannous chloride has the formula $SnCl_2$, and is known as salts of tin. It is used in dyeing and other trades. Stannic chloride has the formula $SnCl_4$, and is also used in dyeing.

One of the most useful properties of tin is its power of forming alloys with other metals. Tin and lead form pewter and various other substances, such as solder and Britannia metal. Tin combined with copper also yields bronze, and what is called speculum metal, which is capable of taking a high polish, that renders it valuable in optical instruments. The chief use of tin is in the making of tin plates.

Lead. Lead is an important metal to which lately new theoretical interest has been attached, since there is actually reason to suppose, as has been briefly mentioned, that it represents the last stage of the atomic evolution, an earlier stage of which is represented by radium. The most important ore of lead is sulphide, the common name of which is *galena*. Commercial lead almost always contains a small proportion of silver, which is now extracted. When pure, the metal is very soft, yielding even to the finger-nail. It melts at the relatively low temperature of 334° C., and its alloys with tin are melted with similar ease. Lead is not attacked at all by dry air, but it is soon dulled by moist air, owing to the formation of an oxide. Lead, of course, is very largely used for the making of pipes and cisterns, and it is a matter of importance to know the conditions under which such lead will remain untouched, and the conditions under which portions of it will be dissolved and carried away in water which may subsequently be drunk. Comparatively large doses of the salts of this metal may be taken with entire impunity. Thus, acute lead poisoning is one of the rarest of occurrences, but the minutest quantities contained in water which is drunk for a long period, may give rise to chronic poisoning, which is unfortunately still exceedingly common, and very often fatal. Chronic lead poisoning also arises from carelessness on the part of workers in lead. The most important precaution which these workers can take is that of scrupulously washing the hands before eating. For obvious reasons, chronic lead poisoning is frequently referred to as "painter's colic." The carbonate of lead ($PbCO_3$, white lead), is one of the commonest of pigments.

The Action of Water on Lead. Let us now carefully inquire into the conditions which determine the action of water on lead pipes and cisterns. Hard water, as it is called, will never cause lead poisoning, because it is incapable of dissolving any lead from the surfaces with which it comes in contact. Hard water always contains free calcium carbonate or calcium sulphate, as we saw in a previous chapter. It is only in the case of soft water that any danger of chronic lead poisoning through the water supply is to be anticipated. Such water usually contains certain organic acids which are derived from the soil, and which may be conveniently included under the general term of humic acid—from the Latin *humus*, the soil. These acids are capable of dissolving lead from pipes or cisterns, and thus giving rise to lead poisoning. Soft water is thus a source of constant danger if used for drinking. A useful little precaution is to allow the tap to run for a few seconds before water is drawn for drinking purposes.

The chief oxide of lead is known as litharge, which has the formula PbO. Another oxide, Pb_3O_4, is known as *red lead*, and is a scarlet powder, which may be obtained by heating litharge. It is used as a pigment, and in making flint glass. When acetic acid acts upon litharge we obtain a white powder, which is the acetate, and which, owing to its sweet taste, is known as *sugar of lead*. It has some small uses in medicine.

The Nitrogen Group of Elements. We must now pass to an important group of five elements—namely, *nitrogen*, *phosphorus*, *arsenic*, *antimony*, and *bismuth*. Not only do these form a distinct group from the chemical point of view, utterly diverse though they are in physical characters, but they also form a recognisable group in the resemblance between their respective actions upon the human body. Much of the most important of these elements is nitrogen, which constitutes about four-fifths of the air, and which must be dealt with in detail.

Nitrogen. *Nitrogen* is a colourless, odourless gas. We inhale it with every breath. It may be obtained in a relatively pure state by several means. For instance, if we pass a current of air through a glass tube filled with red-hot copper, the copper keeps the oxygen while the nitrogen passes on; or we may turn out nitrogen from one of its most familiar compounds, *ammonia*, by means of chlorine. Ammonia has the formula NH_3, and if we pass a current of chlorine through a strong solution of ammonia, the hydrogen combines with the chlorine to form hydrochloric acid, HCl; whilst the nitrogen escapes, and may easily be collected. Other processes also permit of the collection of this element in a pure state from the compounds known as nitrates, which occur abundantly in many parts of the earth. Nitrogen may also be obtained from the complicated organic bodies called proteids. This element is a constituent of protoplasm—the physical basis of life—and therefore occurs in every living thing, whether animal or vegetable, high or low. In marked contrast to its partner oxygen, nitrogen is a very inert substance, having little tendency to combine with other elements. It is scarcely necessary to say that it does not support life or combustion. Its most useful rôle in the atmosphere, according to our present knowledge, is that of diluting the oxygen. Nitrogen is peculiarly insoluble in water. Under suitable conditions it can be burnt or combined with oxygen. Such union occurs as the result of passing an electric spark through the air, and thus—owing to the electrical conditions of the atmosphere, the passage of lightning, and so forth—small proportions of these compounds are found in the atmosphere. The oxides of nitrogen are no less than five in number—as we said in a previous chapter—but of these only one need be further discussed here, and that is known as nitrous oxide, having the formula N_2O. Popularly, it is called *laughing-gas*, and it is of historic interest as the first substance used for the production of general anæsthesia for surgical operations. Its property depends upon its behaviour in relation to the hæmoglobin of the blood, with which it forms a loose compound. It is probable that no single case of death directly attributable to its use can be recorded. It has a faint odour, with which the reader is very likely familiar. Very different is the odour of some of the higher oxides of nitrogen, which cause extreme discomfort and choking.

Phosphorus. This element and the succeeding two in this group, *arsenic* and *antimony*, are often known as *metalloids*, since they have at least some of the properties which we usually associate with metals. There is no free phosphorus in Nature, but the element is found in many rocks and minerals, besides being the necessary ingredient of all but the very lowliest forms of protoplasm or living matter. The element is usually obtained by distilling phosphoric acid (which has the formula H_3PO_4) with carbon. When this mixture is heated to whiteness the phosphorus distils over, and is collected in warm water. The manufacture is not easy, for the element is very ready to unite with oxygen, and burns, forming offensive and dangerous white fumes; thus the element has to be preserved under water. If any moisture be present, phosphorus is phosphorescent, or luminous, in the dark, the cause of this phenomenon being the slow oxidation which occurs on its surface. This ordinary, or *yellow* phosphorus occurs in eight-sided crystals; but we have here another case of allotropy, for if ordinary phosphorus be heated beyond a certain temperature in a closed vessel, or be heated in a tube with a small quantity of iodine, it is converted into another form called *red* phosphorus, usually called amorphous phosphorus, since it is usually non-crystalline. Red phosphorus is not luminous in the dark, since it is not oxidised at ordinary temperatures; it does not catch fire at low temperatures, it is exceedingly insoluble, and in consequence it is quite non-poisonous, whereas ordinary phosphorus is a very dangerous poison, the limit of safety for a medicinal dose being estimated at about one-twentieth of a grain. The most important commercial use of phosphorus is in the manufacture of matches, the chief value of the element in this connection lying in the fact that it catches fire at low temperatures. The ordinary match has phosphorus on its tip; in the case of the safety-match phosphorus is placed on the box. Recent inquiries seem to show that phosphorus may be obtained in a non-poisonous form which is quite efficient for all the purposes of matches. As very substantial danger is attached to the manufacture of matches in which ordinary phosphorus is employed, it is to be hoped that the manufacture of such matches, being superfluous, will shortly cease.

The Oxides of Phosphorus. Phosphorus forms two oxides, which have the respective formulas P_2O_3 and P_2O_5. Like CO_2, each of these is an anhydride of an acid. We need not here go into details of the various acids compounded of hydrogen, phosphorus, and oxygen. Hypophosphorous acid most people have heard of by implication, since its salts—the hypophosphites—have a probably illusory reputation as tonics. The most important acid is known as phosphoric acid, and has the formula already stated. Its anhydride is P_2O_5, which has a great affinity for water, and is used in chemistry for the purpose of removing the last traces of water from substances which are required to be absolutely dry. The reader may be puzzled as to how it is that the anhydride of the acid contains more atoms of oxygen than the acid itself, which certainly looks absurd. In order to solve this difficulty, we must double the formula of phosphoric acid, so that it reads $H_6P_2O_8$. If from this we take three molecules of water, we find that we have P_2O_5 left, according to the equation

$$H_6P_2O_8 = 3H_2O + P_2O_5.$$

The most important salt of phosphoric acid is one of the calcium salts. This phosphate of lime is an essential constituent of plants, and it is absolutely necessary to add it to the soil by one means or another if it is expected to have a continuance of good crops.

Arsenic. This element is occasionally found in the uncombined state, but more usually in the form of a sulphide, often in combination with sulphide of iron. It is most commonly prepared from the mineral known as *mispickel*, which is a combination of these two sulphides. When this ore is heated in earthen vessels, the arsenic comes over in a gaseous state, and can be condensed. Arsenic does not occur in the liquid state, but passes directly from the gaseous to the solid state. It is a steelish grey solid, and is another example of allotropy. If formed by slow condensation, it has a metallic lustre, and is crystalline. If rapidly condensed on a cold surface, it occurs as a black amorphous substance. The reason why arsenic does not liquefy is that, under ordinary conditions, its boiling point is at a lower temperature than its melting point. But if the atmospheric pressure be raised, the boiling point is raised above the melting point, and then the element may be liquefied. Arsenic is used in the manufacture of shot, as it makes the lead harder, and also makes it more readily assume a spherical shape as it drops through the air, which is the process by which shot is made. Arsenic is very largely used in medicine in very minute doses, and there are certain conditions of the skin and other organs in which it is extremely valuable. The great student of drugs, Binz, of Bonn, in Germany, has suggested that it owes its virtues to the property of carrying oxygen from the blood to the tissues. The drug accumulates in the body, however, and must not be given continuously. In large doses, and in chronic poisoning, arsenic causes a series of toxic symptoms, which resemble those caused by phosphorus, its predecessor in this group, and by antimony, its successor.

Antimony. This element is, perhaps, more closely allied to the metals than its predecessors. It occurs in nature in the form of the sulphide, which has the formula Sb_2S_3. Pure antimony can readily be obtained from the sulphide by heating this ore with scrap-iron, which combines with the sulphur, whilst the antimony melts and may be collected from the bottom of the vessel in which the operation is conducted. This element is brittle, bluish white, and crystalline, and melts at the comparatively low temperature of about 450° C. It is only acted upon by air when heated, and then forms the trioxide which has the formula Sb_2O_3, corresponding to that of the sulphide. Alloyed with lead, antimony goes to form *type-metal*. Alloyed with lead and tin, it forms Britannia metal. The introduction of this drug into medicine is usually attributed, as we remarked in our first lesson, to Paracelsus, and the story goes—but we give it only for what it is worth—that the derivation of the name depends upon a certain occasion when he took the opportunity of experimenting with this drug on a community of monks, who were very much disturbed by its unpleasant properties. Hence the name *anti*, against, and *moine*, the French for monk. This element is very much less frequently used in medicine nowadays than formerly. It has a direct antagonism to living matter, and is thus ranked, together with some other substances, such as prussic acid, as a *protoplasmic poison*. Its most characteristic action upon the human body is as an emetic, and its most familiar salt is the compound with tartaric acid, which is known as *tartar-emetic*.

Bismuth. Bismuth is the last metal of this group with which we have to deal. Reference to the table already given will show the reader that we have been dealing with these substances in the order of their atomic weight. Bismuth is exceedingly heavy, its atomic weight being no less than 208. It is prepared from its sulphide in a similar fashion to antimony. This salt occurs in Cornwall, whilst the metal is found native in Saxony. It is of some use in the formation of alloys, for when mixed with lead and tin, and sometimes with cadmium, it forms an alloy which melts considerably below the temperature of boiling water, and which expands when it solidifies. This is known as *fusible metal*. Bismuth forms a couple of oxides BiO_3 and BiO_5, and from these there may be formed salts which are of no particular importance. Two salts of bismuth, however, of no particular interest to the chemist, are largely used in medicine. These are the carbonate and the subnitrate, of which the latter is much the most important. In the treatment of certain affections of the alimentary canal, the subnitrate has no equal. It owes its medicinal properties partly to its weight and its consistence, but chiefly to the fact that it gives off minute quantities of nitric acid just where they are wanted, and is thus indirectly a safe, but powerful antiseptic. Commercial bismuth used to contain arsenic and may also contain traces of the rare metals *selenium* and *tellurium*, the latter of which sometimes imparts an unpleasant odour to the breath. Most pharmacopœias contain a large number of preparations of bismuth, including a number of liquid preparations, which are supposed to act more quickly; but as a matter of fact, these liquid preparations undergo change immediately after they are swallowed, insoluble salts of bismuth being at once thrown down, or *precipitated*, as chemists say. There is thus no reason whatever for preferring them.

We appear to have gone very far indeed from nitrogen, which was the first member of this group; nevertheless, the further we study the chemical and physical and physiological properties of these five elements, the more we are convinced that there must be a relation between them, the nature of which can be guessed in some measure by those who have studied the previous chapters of this course.

Continued

BITUMENS, LEATHER, PAPER, & FIBRES

Tar and Tar Products. Petroleum and Mineral Oils.
Leather. Linoleums. Paper. Textile and other Fibres

Group 20

MATERIALS & STRUCTURES

8

Continued from page 1037

By Professor HENRY ADAMS

BITUMINOUS SUBSTANCES

Tar. *Tar* is the product of the destructive distillation of organic matter. As commercial products there are two principal classes of tar in use: (1) *Wood tar*, the product of the special distillation of several varieties of wood, and (2) *coal tar*, which is primarily a by-product of the distillation of coal in the manufacture of illuminating gases.

Stockholm Tar. *Stockholm tar*, known also as *wood tar* and *Archangel tar*, is prepared principally in the pine forests of central and northern Russia, Finland and Sweden. The material chiefly employed is the resinous stools and roots of the Scotch fir (*Pinus Sylvestris*) and the Siberian larch (*Larix Sibirica*), with other less common fir-tree roots. A large amount of tar is also prepared from the roots of the swamp pine (*Pinus Australis*) in North and South Carolina, Georgia, and Alabama, in the United States. Wood tar is a semi-fluid substance of a dark brown to black colour, with a powerful odour.

The ancient and crude method of obtaining tar is still largely adopted in the North of Europe. The wood to be treated is closely piled up into a huge conical stack or pile on an elevated platform, the sole of which is covered with clay and tiles. The sole slopes inwards from every side to the centre, where an opening communicates with a vaulted cavity under the platform. The pile is closely covered over with layers of turf and earth or sand, to a depth of several inches, leaving near the bottom numerous apertures to admit air to promote ignition. The pile is ignited from below, and as the fire spreads through the heap the various apertures are closed up. About ten days after ignition, tar first begins to flow, and it is at once collected in barrels. In this method several valuable products—the gas, the crude pyroligneous acid, and much charcoal—are lost or wasted, and a more economical process of treating the wood in closed stills or retorts is now largely used in Russia, the gas evolved serving as fuel under the retorts. The heavier tar products of the distillation collect at the bottom of the retort, whence they are carried off by a pipe to a receiver, and the volatile portion passes off at the upper part of the retort, where it is separately condensed.

Wood tar is most largely used as a protective coating for woodwork and other materials much exposed to water and the weather; it is thus of great value in connection with shipping and shipbuilding. A considerable quantity is used in manufacturing tarred ropes and coal-sacks.

Coal Tar. The art of distilling coal for the production of tar was discovered and patented by the Earl of Dundonald in 1787, and till the general introduction of coal gas some amount of coal was yearly distilled in Scotland for the production of coal tar. With the extensive use of coal gas the necessity for this separate distillation ceased, and soon tar was produced in the manufacture of gas in quantities that could not be disposed of. It was burned up for heating gas-retorts, mixed with coal-dust, sawdust, etc., for making patent fuel, and it was distilled for producing a series of hydrocarbon oils, heavy tar, and pitch, and it was only after the discovery of "tar-colours" that the substance came to be valuable; but even now the supply is greatly in excess of the demand.

Pitch. *Pitch* is a thick, tenacious substance, hard when cold, the residuum of tar after its volatile elements have been expelled; it is also obtained from the residues of distilled turpentine. It is manufactured mostly in tar-producing countries, especially Russia, and is largely used to cover the seams of vessels after caulking; it is also used to protect wood from the effect of moisture. Pitch, also, is the basis of the Berlin black, or Brunswick black, used for coating cast-iron goods and for "japanning" preparations.

Creosote. *Creosote* is a product of the distillation of wood tar, more especially that made from beech wood. The distillation of the tar is carried on till only a thick, pitchy substance is left. From the lowest layer of the distillate is obtained, by the action of sodium carbonate, a yellowish oil, the heavier part of which is isolated by rectification in a glass retort and mixed with potash solution to dissolve out its creosote. The creosote is separated from the filtered potash solution by sulphuric acid, is distilled with alkaline water, and again treated with potash and acid, till its purification is effected; it is then distilled at 392° Fahr. and dried by means of calcium chloride. The so-called *coal-tar creosote* is more or less impure carbolic acid, containing paracresol, and other bodies. Creosote has a strong odour and burns with a smoky flame. It has a specific gravity of 1·037. It has been used in surgery and medicine as an antiseptic with great success, but it is now almost superseded by the cheaper and equally efficient carbolic acid. It is also employed for preserving timber from dry-rot and other decay, and for the curing of fish and ham.

Carbolic Acid. *Carbolic acid* (C_6H_5OH) is a substance found in the heavy oil of coal tar, which distils off between the temperatures of 329° and 374° Fahr. When pure, it is colourless and crystallised into needles, which have a burning taste and smell, somewhat like creosote. If taken in large doses it is a poison, but, in small doses, it may be taken internally as a healing agent. Its chief use is as a disinfectant in surgery and as an external application to exposed tissues to exclude or destroy germs. It is the basis of many of the disinfecting compounds of commerce.

Asphalte. *Asphalte*, *Asphaltum*, or *mineral pitch*, so called from the Lacus Asphaltites, or Dead Sea, where it was found in ancient times, is a product of the decomposition of vegetable and animal substances. It is usually found of a black or brownish-black colour, externally not unlike coal, but it varies in consistency from a bright pitchy condition, with a sharp conchoidal fracture to thick viscid masses of mineral tar. Asphaltic deposits exist widely diffused throughout the world, more especially in tropical and sub-tropical regions. It is found in a state of great purity in the interstices of the older rocks, but its occurrence is not characteristic of any particular formation or period. The most remarkable deposit exists in Trinidad, where it forms a lake 99 acres in extent, and of unknown depth, intersected with rivulets of water. In addition to the lake deposit, asphalte occurs in the surrounding country in detached patches, or in sheets of considerable size, and pieces of asphalte are frequently cast up on the neighbouring shores by the sea. A considerable quantity of a fine asphalte is also derived from Cuba, under the name *Chapapote*, or *Mexican asphalte*; and from Peru a very pure variety of high lustre is exported. It occurs in many localities throughout Europe, but not to any considerable extent.

Of greater importance industrially than simple asphalte is asphalte stone—a limestone impregnated with bituminous matter, which occurs in large quantities in several parts of Europe. The most valuable deposits are in the Val de Travers canton of Neufchatel; in the neighbourhood of Seyssel, in France; at Bechelbronn, in Alsace; at Limmer, near the city of Hanover; and at Hölle, in Ditmarschin, etc. Asphalte is now used to an enormous extent in the construction of paving, of which there are two principal methods—first, the mastic process; and secondly, by the hot compressed process.

An artificial asphalte is prepared by boiling up the pitch of gas tar with chalk and sand; but such a substitute, though much cheaper, has not the durability of the natural compound.

Petroleum, or Petrol. The word petroleum is used to designate the forms of bitumen that are of an oily consistence. It passes, by insensible gradations, into the volatile and ethereal *naphthas* on the one hand and the semi-fluid *malthas* or *mineral tars* on the other. It is of great economical importance, especially as a source of light, occurring naturally oozing from crevices in rocks, or floating on the surface of water; and also obtained in very large quantities in various parts of the world by boring into the rock, whence it is termed *rock oil*. By far the largest quantity of oil is obtained from the oil-fields of America. The only other oil-producing region in the world at all comparing with those of the United States is at and near Baku, on the Caspian, where the existence of oil has been known from time immemorial, but where its commercial importance has only recently been realised. It may be said that petroleum has obtained universal diffusion as a lighting agent; it is fast displacing animal and vegetable oils as a lubricator on all classes of bearings, and also where other oils are liable to spontaneous combustion. It is very largely used as fuel for stoves, both for heating and cooking; and it is very successfully used for motor driving purposes. It has also become a useful substance to the apothecary as petroleum jelly or vaseline.

Gasolene. *Gasolene*, or *Gasoline*, is produced by the distillation of petroleum, and is the lightest volatile liquid obtainable. It is used for saturating gas or air in carburetters, and also in vapour-stoves.

Kerosene. *Kerosene* is a product of the distillation of petroleum, coal, bitumen, etc., and consists of a mixture of liquid hydrocarbons. It is practically the same as English paraffin oil, and often goes under the name of mineral oil, or American paraffin oil. It is extensively used in all parts of the world as an illuminating fluid.

Naphtha. The *naphta* known to the ancients was a fluid variety of bitumen, but the more modern *naphtha* is a colourless, artificial liquid obtained by the distillation of crude petroleum. Owing to its cheapness, it is largely used as a solvent in place of benzol and turpentine, for which purpose it forms a substitute often superior to the oil it displaces. It is also used extensively in the manufacture of paints, varnishes, rubber goods, etc., as well as by dyers and cleaners. Naphtha lamps are also used for temporary street lighting; and in vapour-stoves the variety of naphtha known as *stove-gasoline* is used for cooking purposes.

Shale Oil is the name applied in the trade to a certain quality of naphtha.

Benzine. *Benzine*, or *Benzin*, is a colourless liquid consisting of a mixture of volatile hydrocarbons, and obtained by the distillation of petroleum. It is used chiefly as a solvent for fats, resins, etc., and for cleaning fabrics.

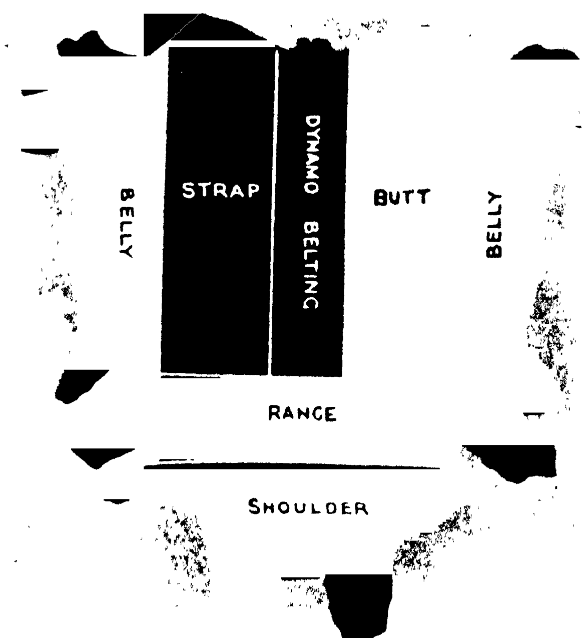
Benzol. *Benzol*, or *Benzene*, which is confounded with benzine, is essentially different from the latter, being a single hydrocarbon of constant composition, while benzine is a mixture of hydrocarbons. To confuse the two further, the colours are the same, and they are both used as solvents.

Paraffin. *Paraffin* is a tasteless, inodorous, fatty matter, obtained by the dry distillation of wood, peat, bituminous coal, etc. It gets its name from the Latin *parum affinis* (little akin) because of its indifference to all reagents. It is largely used for making candles and also as a waterproofing material for fabrics and paper. Other uses are—insulating for electrical work, polishing in laundry work, coating the surface of fruits and vegetables as a preservative, etc. One of the main sources of the paraffin supply is crude petroleum, which yields large quantities in its preparation for commercial use.

Ozokerite. *Ozokerite*, or *mineral wax*, is a mixture of natural paraffins found in the sandstones of the coal-measures. It is brownish-yellow, and in consistency not unlike resinous wax. In some parts it occurs in sufficient quantities to be used for various purposes, and also for making into candles.

LEATHER AND FIBROUS MATERIALS

Leather. *Leather* consists of the hides and skins of certain animals, prepared by chemical and mechanical means in such a manner as to resist influences to which in their natural condition they are subject, and also to give them certain entirely new properties and qualities. Skins in an unprepared, moist condition are readily disintegrated and destroyed by putrefaction, and if they are dried raw they become hard, horny and intractable. The aim of the leather manufacturer is directed principally to overcoming the tendency to putrefaction, to securing suppleness in the material, rendering it impervious to and unalterable by water, and increasing the strength of the skin and its power to resist wear. Leather is made by three processes, or with three classes of substances. Thus we have (1) *tanned leather*, in which the hides and skins are combined with tannin or tannic acid; (2) *tawed leather*, in which skins are prepared with mineral salts; (3) *shamoy leather*, consisting of skins treated with oils or fatty substances.



DIVISION OF THE HIDE

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Tanned Leather. The skins of all mammalians may be made into leather, but in practice it is only from a few of the larger animals, readily obtainable in sufficient numbers and reared and slaughtered for other objects, that commercial supplies are obtained. Of all hides and skins used by the tanner by far the most important and valuable are those obtained from oxen, but of late years horse hides and the skins of the ass, zebra, etc., have become important raw materials of leather, while sheep and goat skins are also very extensively used.

Leather is very largely used in the manufacture of boots and shoes, portmanteaus and hand-bags, machine-belting, harness, hydraulic cup leathers and fire-hose. The whole skin of the ox is divided out into parts according to its thickness and quality, the thickest being used for shoe soles and heavy belting.

Tanning. The actual process of tanning is as follows. The hides, after being prepared, are exposed in a series of pits containing *oozes*. As they are moved from pit to pit of the series the liquid through which they pass contains an ever-increasing strength of tannin until the last pit is reached, when the actual process of colouring or dyeing is completed. The hides are next spread out horizontally in piles in the handling pits and *handled*, or lifted with a tanner's hook at intervals, the one taken out from the bottom of a pile being returned on the top, and so on, this operation lasting about six weeks. The hides are then taken to the *lay-aways* and there exposed to the strongest tannin for a considerable period; then the pits are cleared out, the liquid drained off, and fresh liquid brought in, the operation being repeated three or four times, until the tanning is completed, and the hides are converted into leather.

Tanning Materials. *Tannin*, or tannic acid, is abundantly found in almost all species of the vegetable world, but oak bark and mimosa bark are the chief sources of its production.

Oak Bark was formerly almost the only tanning material used by British tanners, and even now the best quality of heavy goods are prepared by this method. Sole leather prepared by the bark of the English oak is very firm and solid, while other varieties of leather are soft, as for instance, some kinds of French leather prepared from the bark of the evergreen oak. The cork oak (*Quercus suber*), found in the South of Europe, possesses, in addition to its cork, an inner bark, very rich in tannin.

Mimosa bark is obtained from Australasia, from a large number of trees of the *acacia* species. Large quantities of this bark are imported into England, and some of it is very rich in tannin.

Other varieties of bark, producing tannin, are hemlock bark, Scotch fir, and larch barks, willow barks, etc., but these are not extensively used by English tanners.

Tawed Leather. *Tawing* is the term applied to the preparation of leather by the action of mineral substances, such as alum or aluminous salts, on hides and skins. In former times, tawing was used for preparing heavy leather, as machine-belts, heavy gloves, etc., but the system is now almost solely applied to thin and light skins, as sheep, kids, and goats. A large number of white tawed sheepskins are used by perfumers as covers for the tops of bottles, but the most important use to which this system is applied are kid boots, shoes, and gloves, and all kinds of glacé leather.

Shamoy Leather. This method of preparing leather is perhaps the oldest system of all. It consists of impregnating hides and skins with fish oil, for which reason it is sometimes called oil leather; while, owing to the extensive use of deer skin in this system, the product is often known as buck or doe leather. The original name—shamoy—seems to have been derived from the use of chamois skins, while yet another name by which it is known in domestic use is wash-leather, due to the fact that it may be easily washed like a cloth.

Artificial Leather. Under the name of American cloth, large quantities of artificial leather are imported into this country. The most common varieties consist of a calico material, first covered with a thick paste to fill up the pores, and afterwards coated with a mixture of boiled linseed oil, dryers, and lampblack or other colouring matter. The surface is then smoothed and compressed on the calico by passing between metal rollers, and finally coated with copal varnish to produce the glossy finish. It is extensively used for covering chairs, lining tops of writing-tables and desks, and many other upholstery purposes.

Oil-cloth. *Oil-cloth*, or *oil floor-cloth*, consists of a thick canvas backing that was originally painted and ornamented with the brush, but now the designs are applied by means of hand-blocks, or rollers. The thick material has largely given place to linoleum, but a thinner kind is still used for bordering to floor carpets and rugs, and for covering stair-carpets.

Kamptulicon. *Kamptulicon* is a variety of floor-cloth manufactured from a preparation of indiarubber thoroughly mixed with ground cork, the mixture being effected by passing the ingredients repeatedly between grooved rollers. The preparation is next rolled out into sheets, generally over a backing of canvas, by passing through steam-heated rollers. Although indiarubber and cork are the best substances for its manufacture, they are expensive, and cheaper things, as sawdust, gutta-percha, ground leather, asphalte, tar, chalk, etc., have been used. Kamptulicon has practically been displaced by linoleum.

Linoleum. *Linoleum* is a variety of floor-covering made of a preparation of intimately mixed linseed oil and ground cork, spread in a layer over a sheet of canvas. The linseed oil is first boiled with litharge, as in making ordinary boiled oil, and next exposed to the influence of the air in thin films, so as to be thoroughly oxidised. This is done as follows. Sheets of calico are hung up over large open troughs, and the oil is allowed to flow evenly over the surfaces of these sheets, any drippings falling into the troughs. For several days this operation is carried on, until the film of oxidised oil is about half an inch thick, when the sheets are torn to pieces and passed through crushing rollers, which reduce the substance to a plastic mass. This is next placed in a close boiler heated by steam, together with the colouring pigment, and after being thoroughly mixed with "stirrers" it is run off and allowed to solidify into large slabs, which are then cut into blocks about as large as bricks. The cork used is first broken to pieces, then passed through a mill, which grinds it to a powder. The actual operation of manufacture then commences. The blocks of oxidised oil, together with the required amount of ground cork, are put into a kind of pug-mill, thoroughly mixed, and next cut into slices by a revolving knife. These thin sheets are next passed through a series of rollers heated by steam, to the last of which the mixture sticks, and has to be scraped off in the form of a fine powder. This is next spread evenly over the canvas and passed between more rollers, which consolidates the whole mass. The only remaining operation is a coat of paint on the back of the canvas to preserve it.

The best linoleum is inlaid. The pattern runs through the whole thickness instead of being printed on the surface, so that the pattern cannot wear off. It is dry and warm to the feet, and may now be had in carpet patterns. All these varieties of floor coverings, however, exclude the air from the floor boards, and make them more susceptible to dry-rot. There is, however, little danger, unless moist stagnant air reaches the boards from their under side.

Cork. *Cork* is the outer bark of the evergreen species of oak (*Quercus suber*) which flourishes in the South of Europe and North of Africa, more especially in Spain and Portugal. Year after year additional layers are added to the inside of the outer bark until it becomes a thick, soft mass, possessing peculiar elastic properties which give to cork its value. The trees are first stripped when they are about 20 years old, this first yield being called virgin cork. It is rough, has a woody texture, and is not of much use except for forming rustic work in conservatories and as a tanning substance. After the first stripping the bark is removed every eight or ten years, the quality improving with each stripping. Cork is used for many purposes, as bungs and stoppers for bottles, hat linings, artificial limbs, etc., while, owing to its light specific gravity and durability, it is almost universally used for making various life-saving appliances, as belts, jackets, buoys, and parts of lifeboats. In a granulated form it is largely used as a non-conducting filling for cold-storage.

Charcoal. *Charcoal* is the more or less impure variety of carbon obtained from animal and vegetable materials by heating to redness in a vessel which is nearly closed, the volatile matters being thus driven off.

Animal charcoal, also called *Bone-black*, is made by igniting bones, which have been boiled to remove fat, in closed vessels of earthenware or iron. It is used as a decolourising and filtering agent, and may be re-purified after use by treating with acids. Animal charcoal is used as a pigment, in the form of ivory black, and also as a manure for sour vegetable soils. *Wood charcoal* is a hard, brittle substance, with a clear ringing sound when struck, made from a large variety of trees, as oak, ash, birch, Scotch fir, elm, beech, chestnut, etc. It is used as a fuel, particularly in France, as a reducing agent in metallurgy, in the manufacture of filters, and in medicinal work. The use of charcoal filters for drinking water is now universally condemned, but there are other cases where it furnishes a suitable filtering medium.

Torgament. *Torgament* is the name given to a pasty material, composed of asbestos and other silicates, which is used as a permanent floor or wall covering. It sets into a hard, jointless surface, proof against dry-rot and damage by fire or water. It can be easily washed or cleansed, is very durable, does not crack, does not harbour dust, vermin, or bacteria, is impervious to rodents, and, from its hygienic advantages, is coming into use for hospitals and infirmaries. It may be waxed and polished, or left with a non-slipping surface, without altering its character. The colour may be varied as desired.

Stonuood flooring, and the *jointless sanitary flooring*, made by Messrs. Smith Brothers, are very similar to torgament.

PAPER

Paper consists of a thin, compact web of vegetable fibres artificially prepared and most largely used for writing and printing. The name is derived from the *Papyrus* plant of Egypt, whose leaves were used for writing upon before the invention of paper.

Writing and Printing Papers. Writing and printing papers of the best quality are made from rags, which are first cut into pieces about the size of the hand, then separated into linen and cotton of different qualities, and each lot placed in a separate receptacle, after being subjected to the *willow* and *duster* to knock out the dust. The rags are next placed in what is known as a *rag-boiler*, which is then half filled with water, and a quantity of caustic soda, varying with the nature of the rags, is added. After boiling for 10 or 12 hours they are washed with cold water and afterwards picked over to separate any impurities. The rags are next passed to the *breaking engine*, which cuts them into fragments, and a solution of chloride of lime is added for bleaching purposes, after which the pulp is run into large stone chests, where it is allowed to remain until quite white. It is then pressed to remove as much as possible of the bleaching solution. The bleached pulp is next passed to the *beating engine*, where it is washed to free it from any remaining solution, and then subjected to the beating operation, during which the loading material, such as pearl white or china clay, is added, except in the case of hand-made paper, when nothing is added. This addition of mineral matter weakens the paper to a certain extent, but it closes up the pores, so that it will take a better finish. The next operation is the sizing, consisting of a mixture of resin soap treated with alum, which forms a comparatively waterproof covering. If the paper is to be tinted, it is generally accomplished by the use of aniline colours, and all coloured papers are produced by the use of various pigments.

Hand-made Paper. *Hand-made paper*, so far as the manufacture of the pulp is concerned, is done in the same way as writing and printing paper just described. The wet pulp is then spread evenly over a mould of fine wirecloth, through which the moisture drains, leaving the dry pulp. This is then turned over on to a sheet of felt, and the operation repeated until the required number of layers of pulp between felt sheets are obtained. They are then placed in a pile and taken to a press, which presses out the greater part of the remaining water, leaving the paper sufficiently dry to be handled. The sheets are then parted and each separately re-pressed, after which they are hung up in spurs of three or five sheets to dry. The spurs are next passed through a trough containing the sizing material, which is a strong solution of gelatin, and sent between rollers on an endless band of felt to take off the superfluous size, and the sheets are then carefully parted, to prevent sticking, and again dried. They are then packed and glazed between plates, and afterwards sorted and finished in the same way as other paper, only with more care

Blotting Paper. *Blotting paper* is a coarse, unsized paper of a spongy character, used for absorbing the superfluous ink from freshly written paper Lithograph and multiplex copying papers and many printing papers are more or less of the same character, as they then take printing ink better, which is not liable to run as writing ink would do.

Esparto Paper. Although all the better qualities of paper are made from rags, the demand for material is so large that other sources of supply have to be tapped for the cheaper qualities of paper, and perhaps the first among these is *esparto*. The grass is first sorted and then boiled in the same way as rags, but with a more liberal proportion of caustic soda. The rest of the operation of manufacture differs very little from that of rags, more bleaching solution being required, and the resulting paper is of a more bulky nature, admirably suited for printing purposes.

Straw Paper. A large quantity of straw is used in England and America for paper-making, but it is usually mixed with either rags or esparto, as it is too brittle to use alone. It is first dusted, then in many cases cut into chaff, and boiled under high pressure with caustic soda, after which it is washed and bleached in the usual manner.

Wood Paper. Wood is another material that is largely used in the manufacture of paper. The wood selected is generally poplar or white pine. This is cut into slabs, which, by one process, are pressed against a mill-stone running at high speed, the fibres as they are separated being taken away, sorted according to fineness, and pressed into pulp or half stuff, which is sometimes made into paper alone, but it is more often used as an admixture for making inferior paper. There are also other ways of preparing the wood in a chemical manner. The wood is also prepared by being fed against revolving steel cutters, which reduce it to small chips ready for maceration into pulp.

Brown Paper. *Brown paper* is the general name applied to wrapping papers of all qualities and materials that are of a brown colour. The coarser varieties are made from old rope or unbleached manila and used for all kinds of wrapping purposes. When painted over with boiled linseed oil it makes a useful packing paper for machinery.

Wallpaper. *Wallpaper* is the mural decoration most generally used at the present time, and takes the place of the more costly textile hangings of earlier times. Wallpaper dates back to the sixteenth century, but it did not come into general use until the eighteenth century, while of late years well-known designers have devoted their sole attention to the subject, with the result that many splendid varieties are now produced.

The best wallpapers are printed by hand from wooden blocks upon which the pattern is cut, the outlines being formed of brass or copper strips set edgeways in the wood, requiring a separate block for each colour.

The cheaper kinds of wallpaper are produced by machinery, the pattern being printed from rollers. The machine-made papers will scarcely bare comparison with hand-made papers, either for quality of tint or finish.

Stencilling. *Stencilling* is another, and, if not too elaborate, still cheaper method of decorating the plastered surfaces of walls and ceilings. The pattern is cut out of thin sheets of zinc or Bristol board, and so arranged that all the parts are held in position by small pieces called "ties," which are left in for the purpose. In the stencil the parts which are to appear in colour on the prepared surface are holes, while the parts to be left untouched on the surface are filled in solid on the stencil plate.

FIBRES IN GENERAL USE

For a full description of these materials reference must be made to the section on TEXTILES.

Hemp. *Hemp*, as known to commerce, is a tough, strong fibre obtained from the rind or skin of the hemp plant—by rotting the stalks under moisture—and afterwards prepared in various ways for use in manufacture It is extensively used for weaving into coarse fabrics such as sailcloth, and also for twisting into cables and ropes. The plant is a native of Central and Western Asia, and is largely cultivated in India, but it has also been introduced into parts of Africa and Brazil, and is extensively cultivated in many other countries.

Jute. *Jute* is the product of various plants of the *Corchorus* family, but the jute fibre of commerce is only produced by the two species, *C. capsularis* and *C. olitorius*, both of which are natives of Bengal. The fibre of the plant, which is glossy and capable of such fine division as to mix with silk, is obtained by maceration from the inner bark. It is largely used in Bengal for the manufacture of gunny bags, and is also used for making inferior ropes, but as it will not stand the moisture, jute ropes are not of much use. The refuse of jute may be made into a good quality paper.

Coco-nut Fibre. *Coco-nut fibre*, or *coir*, is the name given to the substance of the fibrous husk, or rind, surrounding the hard shells which enclose the coco-nuts, or fruit of the coco-nut palm. The coir or fibre is manufactured into matting, bags, brushes, etc. The refuse is used by horticulturists to cover the soil in carpet bedding, to protect bulbs from slugs, to pack between pots of cuttings, and for other purposes.

Rope. *Rope* is technically the name given to a cord over 1 inch in circumference, but the name is commonly applied to any thick cord. Smaller ropes are called *lines*. Ropes may be divided into two kinds: (1) Those made of hemp, manila, flax, cotton, and other fibre; and (2) those of iron, steel or other wire. Ordinary ropes are usually of hemp, and are composed of a number of threads or yarns, first spun into strands which are afterwards twisted or *laid* right-handed together to form the finished rope. Each rope has a different name, according to the number of strands it contains.

Flax. *Flax*, or *lint*, is the name employed to denote both the so-called fibre and the plant from which it is produced. The flax is really the remaining fibres of the stems of the plant after the superfluous matter has been removed by either one of the methods known as *water-retting* or rotting, and *dew-retting*, of which the former is the more widely used. The fibres, when produced, are used in the manufacture of linen cloth and thread, cambric, lace, etc.

Canvas. *Canvas* is a heavy woven cloth of hemp or flax fibres, used for any purpose where great strength is required—such, for instance, as sailcloth; and so extensively has it been used for this purpose that the term canvas in now often employed in speaking of the sails of ships. Originally, canvas was made from hemp, and the name is a corruption of *Cannabis*, which is the scientific name for the hemp plant; but the canvas made from linen or other fabrics is now generally preferred. Other purposes to which it is put are grounds for oil paintings, backing for linoleum, etc.

Cotton. *Cotton* is a white fibrous substance, the product of the cotton plants, *Gossypium barbadense*, or sea-island cotton, yielding fine, long staple or pile; the *G. herbaceum*, yielding the short staple or upland cotton of America; beside many other varieties. But of them all, the first mentioned is by far the most important in commerce, owing to the length of its fibres.

Cotton is used as the most widely adopted clothing material for the human race, in the manufacture of thread, and in surgery as a dressing for burns, etc.; while, when cotton is acted upon by nitric acid, it yields the powerful explosive known as guncotton.

Cotton-wool is a raw cotton or cotton fibre either on the boll or prepared for use. It is the well-known fluffy material used for many purposes. For surgical use, it is treated with an antiseptic and known as *medicated* wool.

Wool. *Wool* is a soft, curly hair which forms the coat of sheep and some other animals, as the Alpaca and Angora goat. The wool or fleece of sheep forms by far the most important clothing material in all cool climates, and it may be taken as the finest variety of the substance, as the coats of some animals run by almost imperceptible degreees from wool to hair. When shorn, wool is divided into two classes—*long*, or *combing wool*, and *short*, or *carding wool*—which latter seldom exceeds 3 in. or 4 in. long and produces the finer varieties, while the long staple makes the coarser kinds. The wools, *carding* and *combing*, obtain their names from the manner in which they are worked—the former being worked on a carding machine, while the latter is prepared for spinning by combing.

Cloth. *Cloth* is a fabric formed by weaving threads of cotton, hemp, flax, or other vegetable fibre, or a texture of hair or wool. It is used for making clothing, and coverings of all kinds, as well as for many purposes too numerous to mention here.

Felt. *Felt* is an unwoven fabric of short hair, wool, or fur, the fibres being matted together by a kind of mutual adhesion. The hairs which contain the best felting properties are mohair, alpaca, camel hair, beaver hair, and rabbit hair, the last mentioned especially supplying the finer felts used for hat-making.

Lining felt as used in building, is a coarse felt placed between two layers of boards or on the inner surface of walls as a non-conductor of heat and also to deaden sound. A similar fabric, made of asbestos and hair, sometimes mixed with a lime cement, is used as a non-conducting covering for boilers and steam pipes, and there are many other varieties of coverings for the purpose based upon the same general principles.

Roofing Felt. *Roofing felt* is a somewhat similar material to lining felt, used for covering roofs. It is not a true felt, but a mixture of hair or other animal fibre compounded with a tar preparation, and rolled into sheets, which are nailed in the required position, and, if not otherwise covered, they are then coated with tar and sanded to hold the tar when exposed to the sun's rays.

Ruberoid is a roofing felt, saturated and coated with a patent compound which is said to be non-oxidising, water-, acid-, alkali-, and weather-proof. Its foundation is wool felt, and although it looks like millboard covered with rubber, having a smooth or slightly ribbed surface, the makers state that no paper is used in the manufacture, and that it contains no tar, pitch, rubber, asphalte, or other short-lived ingredients. It is used as a sarking felt, an external roof covering, and as a damp-proof course in walls.

Impregnated Foundation Felt. This is another wool felt material, prepared in various thicknesses, for insertion under machinery foundations to prevent vibration and deaden sound, and may be used under floors as a non-conductor. It is durable, resilient, weather-proof, and fire-resisting.

SUNDRY MATERIALS

Dextrine. *Dextrine*, also called starch gum, and gommeline, is a white gummy substance of the same composition as starch. It is largely used in the arts and medicinal work as a substitute for gum arabic.

Alabaster. *Alabaster* is a mineral, not unlike marble, of a colour varying through shades of red, yellow and grey; but the most valuable varieties are pure white, as, for example, that found in Italy, near Florence. There are two distinct kinds of alabaster—(1) the gypseous or granular variety, or sulphate of lime; and (2) the calcareous variety, or carbonate of calcium, which was the alabaster used in ancient times. Alabaster, being soft, can be turned with a lathe or carved with a knife, and is largely used for making vases, statuettes, and other small works of art.

Blue-John. This is the local name given in Derbyshire to a blue variety of fluorspar. The name was first applied by the miners who discovered it, in order to distinguish it from the ore of zinc, known as *Black Jack*.

Blue-Billy. This is the name applied to the residuum of pyrites after the manufacture of sulphuric acid or sulphur has been carried out. It is largely used for repairing puddling furnaces in some parts of the country. This name is also given to the quicklime removed from gas purifiers.

Continued

Group 4

BUILDING

8

Continued from page 920

SCAFFOLDING, STAGING AND GANTRIES

The Various Systems Employed for Different Purposes. External and Internal Platforms. Piling and Strutting. Derrick Stagings

By Professor R. ELSEY SMITH and W. HORNER

SCAFFOLDING

Before any building has been raised far above the ground level, the work will be out of reach of a man standing on the ground, who cannot do satisfactory work at a level of more than 5 ft. at the outside above the ground upon which he stands. Platforms must be erected at successive heights as the building grows, that work may be carried on and material for immediate use may be stored. The term *scaffold* is applied to such platforms and the framework arranged to carry them.

A Bricklayers' Scaffold. A bricklayers' scaffold [62] consists in this country of a temporary framework of circular fir poles of various sizes and lengths, which are lashed together with cords of hemp or of galvanised iron wire. This lashing is termed *tying*. The average size of a pole may be taken to be about 5 in. in diameter, with a length of 30 ft. The frame of the scaffold is formed with a series of vertical posts, termed *standards*. These are placed about 8 ft. apart, and at a distance of 4 to 5 ft. from the face of the wall. The foot of each standard is, if circumstances permit, imbedded for about 2 ft. in the ground; but if it is to stand on a pavement, as in a street, it may be placed in a large tub filled with earth, or, when in position, may be surrounded with a mass of concrete, the object in either case being to keep the foot from shifting.

For scaffolds of moderate height each standard consists of a single pole, and may be extended upwards by lashing another pole to it. Where a lofty scaffold is to be erected, the standards may be formed throughout of two poles of unequal length lashed side by side, so that, when extended upwards, the poles will be jointed at different levels, thus breaking the position of the joints and rendering the work stiffer. The lashing of two such poles together is termed *marrying*.

Similar fir poles are placed horizontally against the standards and are securely lashed to them. These are termed *ledgers*. They are placed at intervals of 5 ft.—which distance is termed a scaffold height—right up to the highest level necessary for the building. To stiffen the structure thus formed, especially in exposed sites, poles are placed diagonally from the base of the scaffold to the top, and are lashed to both standards and ledgers to prevent any racking of the scaffold.

Erecting the Scaffold. In this way a light, strong frame is constructed parallel with the face of the wall to be built. It is not completed before the work starts, but grows with it, the height of standards being increased and additional ledgers added as required.

The lashing of the framework is carried out by means of scaffold cords (which are 8 ft. lengths of manilla rope whipped at both ends) twisted several times round the two poles to be united, whether they are at right angles or side by side. The scaffolder's principal tool consists of a special hammer with a spur projecting from it. In tying, the cord may be twisted round the handle, the head placed against the pole as a fulcrum, so as to draw the cord tight. The cords are fastened off by threading the ends under two or three turns. The hammer is also used for forcing the cord into position. When the lashing is completed, pointed wedges having one side flat and the other round are inserted between the pole and the cord, and driven in to tighten up the joint further and left in position. Such cords are liable to shrink in wet weather and to stretch again in hot, dry weather, and under such conditions the scaffold must be examined and the wedges tightened up.

The wire cords are not liable to be affected by weather in this way, and can, in most cases, be tied sufficiently tightly without employing wedges.

Platforms. The platforms are formed as follows: The brickwork having been carried up to the level of the top of the fresh ledger, small square timbers, termed *putlogs*, usually split out of birch, about 3 in. square and 5 ft. long, are laid about 4 ft. apart, one end resting for about 4 in. on the brick wall and the other end on the ledger, and some of them, at least, are secured to the ledger.

On these timbers *scaffold boards* are laid side by side: these are usually about 12 ft. long, 9 in. wide, and 1½ in. thick. The square corners are splayed, and the ends are protected with a strip of hoop-iron nailed to the board, which prevents them from splitting. To form working platforms these are laid side by side across the putlogs and the full width from the wall to the ledger, and the ends are butted one against the other. At such joints two putlogs are placed close together, each supporting the ends of one set of boards. Boards sometimes have the ends lapped, but this is not so good a method, and in no case should the end of any board be left without a support under it, or it may tip up if stepped upon and cause an accident. Along the outer edge vertical *guard boards*, to prevent materials falling off, are fixed, and at a height of 3 ft. 6 in. a rail is fixed for the protection of the workmen.

Runs. Runs may also be formed from one part of a scaffold to another, and should not be less than 18 in. wide. These are formed of two boards (or more) laid side by side, and they should be joined together by strips of wood nailed at intervals on the underside.

The lowest platform of all is left permanently in position, and, if next a street, must have a double layer of boarding to prevent dust and rubbish from falling through. The other stages are removed successively as the work proceeds, and are re-erected at a higher level.

The foreman must see that the scaffolder prepares each stage in advance of the bricklayers' requirements, so that there may be no delay. As the wall is built up from any stage, a half-brick is omitted, where the putlog rests on the wall. This is known as a *putlog hole*, and is filled in later as the scaffold is taken down. If the *pointing* [see BRICKLAYER] of the wall is left to the finish, the stages must be temporarily reinstated to execute this work, and the putlog holes are filled at the same time.

Internal Scaffold. The frame described is assumed to be placed on the outer side of the wall, but a similar frame and platforms must in many cases be erected on the inner side, otherwise the bricklayers would have to work on the inner face *overhand*—that is, by leaning over the wall to set the inner bricks, and such work is not capable of a finish equal to that executed in the ordinary manner. The inside scaffold is often slighter and less complete, and advantage may be taken of cross walls to support the ledgers.

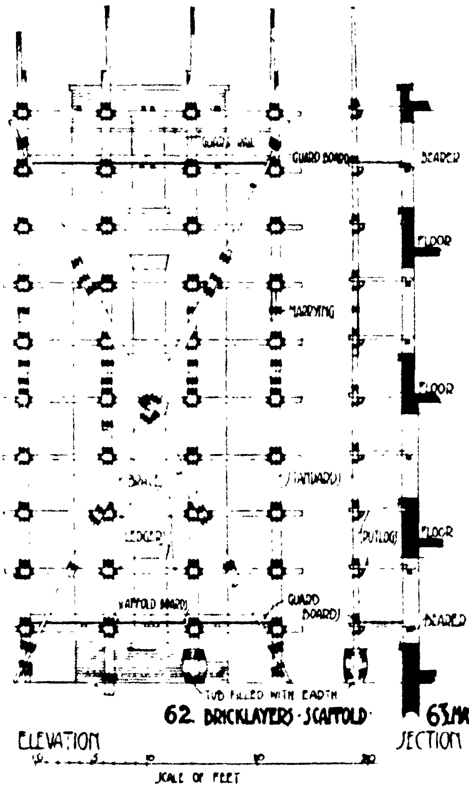
Cross Bracing. In addition to the bracing already described in the plane of the framework, it is desirable wherever inner and outer frames are employed to tie them together.

This may be done where door and window openings occur, and contributes to the rigidity of the scaffold, and particularly in exposed situations helps to resist the action of the wind, which often tends to force the whole scaffold out of the perpendicular. On open sites poles may be erected in the form of raking struts to steady the outer scaffold when it cannot be tied to the inner one.

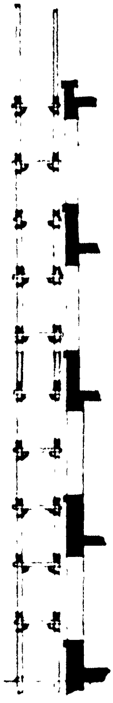
A Masons' Scaffold [63]. A masons' scaffold resembles a bricklayers' scaffold, but when a wall is built of large stones, there are no longer the facilities afforded by brickwork, of forming putlog holes to take the inner ends of the putlogs, and two frames are required, one usually about 5 ft. from the wall and the inner one about 6 in. only from it.

The materials to be dealt with are often much heavier than in the case of brickwork, and the standards may be placed nearer together and braced more rigidly to provide adequate support, and they must be secured so that there is no risk that they will lean away from the face of the wall.

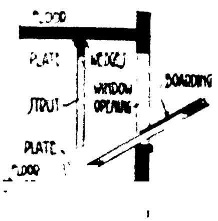
The illustration [62] shows a scaffold suitable for the erection of a small building of considerable



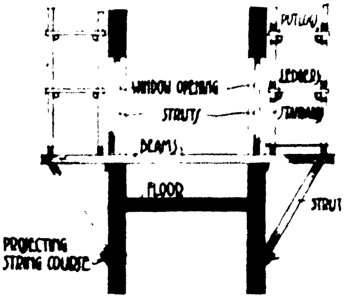
62. BRICKLAYERS' SCAFFOLD



63. MASONS' SCAFFOLD



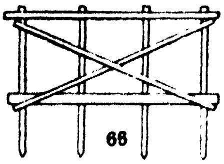
64. PROTECTING FAN



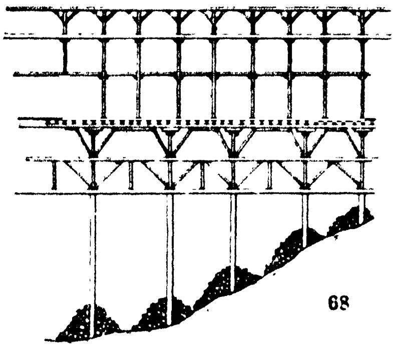
65. SECTION OF A SCAFFOLD ERECTED ABOUT A TOWER ABOVE THE GROUND LEVEL.

height, such as a detached sanitary tower of a *hospital.*

Ladders. Access to various parts of the scaffold is provided by ladders. They are made of various lengths, and are described by the number of rungs they possess. Very long ladders are often used for repairing and painting work, but in connection with scaffolding, ladders of moderate length are used. Where a great height has to be reached, several ladders are employed, and a platform is provided on which to land from each before climbing the next. The foot and head of each ladder must be firmly lashed or otherwise secured, and a strut is provided from the scaffold about the centre of the ladder to prevent oscillation.


66

Hoisting Material. Materials are often carried up by labourers in hods or baskets. For larger buildings, the height of which is not great, a kind of well-hole or run is provided at some convenient spot, and lined with scaffold boards placed vertically to enclose it on two or three sides. Materials are hoisted in barrows or baskets by means of a pulley and windlass worked by hand or by a small engine. For large works one or more derrick cranes are used, and by their means materials can be hoisted from carts and deposited directly at any desired spot. Small materials such as bricks, are packed in crates and hoisted in bulk. Large stones, timbers, ironwork, etc., are dealt with separately, and great care must be taken to see that they are properly secured before they are lifted.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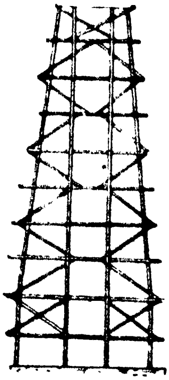
In executing repairs, a scaffold may sometimes be erected round the upper part of a building without being built up from the ground. In the case of a tower, for example [65], strong beams may be passed through any suitable opening, extending from side to side of the tower so that the load on the two ends will counterbalance and form a base on which a scaffold may be constructed. The outer ends of these timbers may often be strutted from a projecting string course at a lower level. Where the beam cannot or is not required to pass right through the building, the inner end must be secured against any tendency to tilt up by being strutted against an upper floor.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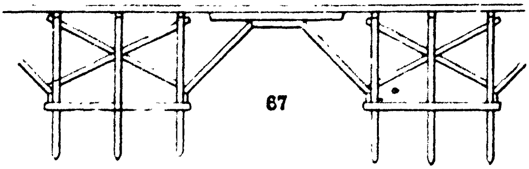
Protecting Fans. Where such work has to be executed adjoining a public thoroughfare, and where old buildings are being pulled down, wooden fans are aften formed for the protection of the public [64]. They are constructed in the manner just indicated; bearers are passed through the available window openings but are not placed horizontally as for a scaffold, but inclined upwards, and the inner ends are securely fixed. The outer ends are covered with boards or cross bearers, and are placed, if required, to receive the close boarding. Various forms of patent standards for scaffolding and extending scaffolds are to be hired or purchased, and are useful for special forms of work, but the ordinary scaffold as above described remains in general use.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Sling Scaffolds. Sling scaffolds, or boats, are used especially for painters' work. They require a strong projecting beam fixed above the level at which work is to be executed. From this a small stage or platform, protected by rails and large enough for one or two workmen, is suspended by cords and pulleys, and can be raised and lowered at will. The cords and tackle used for hoisting such boats must be thoroughly examined periodically to see that they are in a perfectly sound condition.

STAGINGS AND GANTRIES

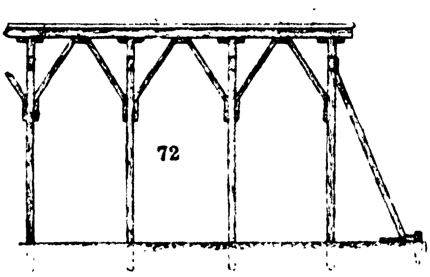
The bricklayers' scaffolding made of poles and ledgers, lashed together with ropes, and supporting putlogs and planks, have but a limited service in engineers' work, which is generally of so exacting and varied a character that something much more substantial is required. The stagings of the engineer are used for the erection of girder bridges, viaducts, steel roofs, piers, and allied work, taking the place of the centring of the bridges of stone and brickwork. The scaffolding of the engineer has to carry massive girders of steel, and often besides cranes and tackle for hoisting the same. These "temporary works," as they are called, are often constructed of steel, but with these we are not concerned. They are of rather a costly character, even though built of timber, because of the large quantity required and the labour engaged in their construction.

Gantries. There is also a type of staging better known under the term gantries, the functions of which may be identical with, or different from, the foregoing. Gantries are built for the erection of work simply, or they are structures for carrying travelling cranes, or erecting towers, or skips, etc. The difference in the two is rather in function than in essential form or design. In the case of many architectural works of a large and substantial character, especially when masonry is much used, various forms of gantries, including derrick platforms, are very generally employed.

Trestles. Allied to these, again, are the trestles, or clusters of braced standards used for carrying horizontal staging, the timber staging for derrick cranes, the towers for aerial ropeways, all having this in common, the cross bracing of vertical members otherwise liable to bend and yield under loads.

Stagings, again, may be broadly divided in two groups—the fixed and the portable. The first is the more common, the second being used chiefly for the erection of bridges over deep streams into which piles cannot be driven. It is also employed in erecting gasholders.

Methods of Union. One feature which all these structures have in common is the method of union of the timbers. As these consist of balks, mostly with some half timbers and plank decking, the fine work of the joiner is out of the question. The stub tenon and the joggle predominate, and the real agents of union are chiefly bolts, dogs, and spikes. The tenons and joggles prevent slipping of the timbers over one another, but their security depends on the bolt and other fastenings employed.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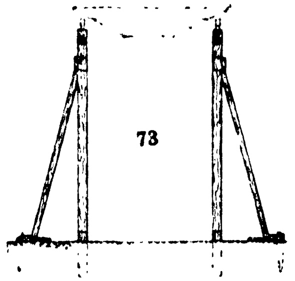
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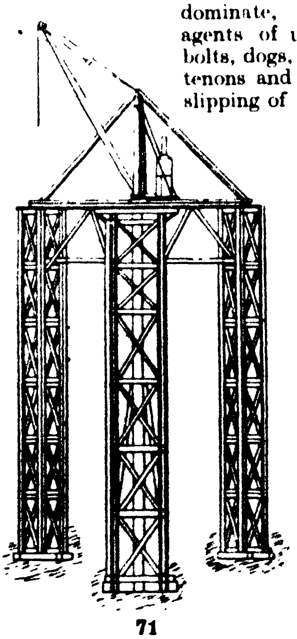
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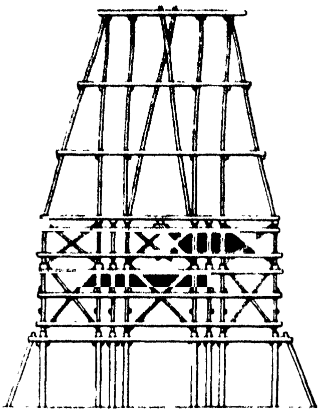
Bracing and Struts. Another essential characteristic is that bracings and struts enter largely into construction. The taller and longer the structures the more importance do these assume. It is a familiar fact that one diagonal brace will prevent a rectangular frame from "going cross-cornered"—in other words, assuming the form of a rhombus. This fact illustrates one of the functions of bracings and struttings. But another of equal importance is that bracing puts the tall standards into the condition of short columns. This means that the tall sticks of timber, even though, say, 12 in square, are very weak, and would bend and yield if unbraced, but when several of these are connected with diagonal bracings the strength becomes that of short columns of large area of base.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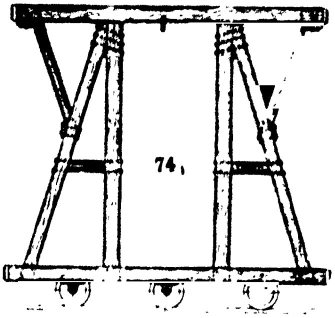
Fixed Stagings. Fixed stagings on land are built on squared timbers (balks) sunk into holes dug several feet deep in the ground, and loaded round with large stones. The ends are well tarred first. Similar stagings in streams or on dock sides, or on breakwater and pier work, are built on squared piles [**66** and **67**] shod with steel and driven into the soil. The real work lies here, since the difficulties are greater than with superstructural portions. Good piling is a firm foundation on which to build.

Piling. Piles are rendered capable of supporting a superincumbent load either by their reaching firm ground, or, when no such ground exists, by the friction of their sides against the soil. Much difference of opinion exists in regard to each of these, but when an ordinary monkey, let fall from its full height, fails to move a pile more than ⅛ in. or ¼ in., it is considered that the pile has found a firm bottom.

The spacing of the piles is settled by the load upon them. About 1,000 lb. per square inch of head is a safe load.

Stability is often studied by driving piles in diagonal directions instead of perpendicularly, imitating the batter of walls, and thus increasing the width of the base considerably. This can only be done in one direction as a rule, the



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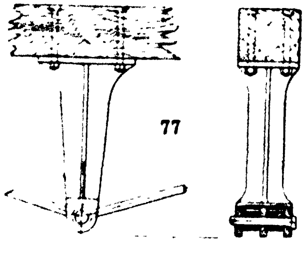

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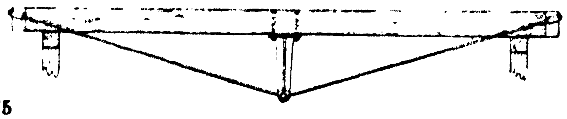

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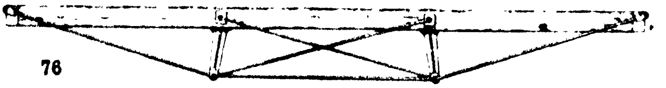

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exception being a structure with a base of square or oblong form.

It is not sufficient to drive piles firmly ; they must be tied together in some way so as to enable them to withstand the rolling or rocking loads to which they will be subject. Piles are often tied together by straining chains with a tightening screw. The chains are attached to the piles which form the four corners of an enclosed rectangle, and are screwed up taut. Sometimes the fastening down of the cross timbers and decking are sufficient, but more often, especially in deep piling, the timbers have to be strutted [67 – 71] or connected with diagonal bolts crossing each other. It is not usual to place much reliance on bolt fastenings or on the end contact of timbers for stability, but to trust more to the judicious crossing and strutting, which prevent initial movements.

The uprights or standards of stagings erected on land [71—73] have the same functions as piles driven under water, and the remarks just made respecting tying them together and stiffening with struts or crossing bolts apply whether the stagings are fixed or mounted on wheels.

Strutting. The strutting of main timbers when done properly renders movement in any direction in the plane of the struts impossible. The strutting is made double, equal, and in opposite directions, for this purpose ; the stress tending to move the structure as on a pivot to right hand or left is met by its strut or set of struts. The struts must, therefore, be provided with some suitable resistance. Here it should be obvious that no mere tenoned joint would hold the members firmly. Though stub tenons are sometimes used to prevent slipping sideways, they are never relied on alone, but straining pieces, joggles, or abutment pieces, as they are variously termed [67, 68, 72, and 73], are employed. They may be long pieces bolted or spiked to the main timbers, or short chocks only, similarly fastened as shown in 72 and 73. These take the stresses on the struts, but the latter must be also bolted or dogged securely to the main timbers, the bolts passing through and their heads and nuts resting on iron washers. The dogs are simply driven in just as the carpenter drives his little dogs or staples temporarily into timber. Too many bolts in timbers are objectionable, not only because they cost more to make and fit than dogs, but also because the bolt-holes lessen the value of the timber for sale. This, of course, only applies to temporary works.

Horizontals. The upper horizontal timbers must be adequately supported. If the piling or the standards are not very far apart, the horizontal timbers generally require no other support. Frequently, however, two sets of horizontals are used, laid one over the other, crossing at right angles. But, apart from this device, horizontals must be stiffened if they are supported only at long intervals. This is done either by strutting [72], or by trussing [75 and 76]. The first named is less costly than the second. But when timbers are very long, trussing is the only method practicable, and this may be single [75] or double [76]. In this the stresses tending to bend the timber downwards are transmitted to the truss or tie-rods, which are anchored at the timber ends, and in a strut of cast iron [77], or two such struts, fastened to, and projecting from, the bottom face of the beam. This device is not often adopted in temporary stagings, but it is usual in permanent gantries.

Tall Stagings. Tall stagings [68, 69, and 70] are essentially a multiplication of the single staging. They are necessary where the girders for bridges and viaducts have to be carried across deep ravines. They are made broader at the base [69 and 70] than above, and the main members form several tiers, which are each strutted similarly to a single element. Around this general design engineers effect all kinds of modifications adapted to any particular piece of erection in hand.

Portable Stagings. Portable stagings embody the principles of construction of the foregoing in so far as the strutting and union of the members is concerned. The difference is that, instead of fixed piles or standards, the staging is mounted on flanged wheels [74], to run on rails, if on land, or is placed on a pontoon, or pontoons, if for bridge erection.

Bridge-erecting Stages. The stagings for the erection of bridges are of two kinds—those having the piles or standards spaced equally, and those in which they are clustered. The difference between the two is as follows.

Equal Spacing. Here the bridge is erected on stagings which are placed at regular intervals [68], excepting near the centre of the waterway, where a space of double or treble that allowed elsewhere is given, in order to permit of navigation there. But at any other locality the stagings bar traffic. This method is only suitable where streams are not liable to flood or to drifting ice. It is a simpler construction than the cluster device, but in some cases uses a larger quantity of timber.

The Cluster System. In this [69 and 70] navigation is scarcely impeded, since the clustered standards are spaced widely apart. But this involves the connection of the tops of the standards by horizontal beams, so making a gantry. These beams of timber or steel are generally both trussed and strutted, to enable them to carry cranes and the loads of the bridge girders.

The standards for staging must consist of piles in swift streams, and in those like the rivers of Canada and North America, where floating ice comes down. It is also safer in slow-running navigable streams.

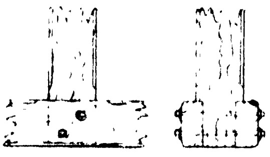
There are many cases in which it is not necessary to drive piles, but the standards are instead stood on the river bed and enclosed with a mass of rubble [68], to prevent them from shifting. Or the two methods are used in combination, some standards being driven, others not, and the bases loaded with rubble and the upper portions braced. On land, standards are sometimes carried on horizontal timbers [71], as, of course, they must be also when a travelling staging is mounted on wheels [74].

Choice of Methods. What particular method shall be adopted in any case is a question for settlement by the engineer, who has to take all the local circumstances into consideration. The nature of the ground, the span, height, wind pressure, navigation, etc., all have to enter into the calculation, and a matter as important as any is that of cost.

Alternatives to Stagings. The staging method of erection of bridges is alternative to that of floating out bridge girders, or rolling them out from the shore, or building them out from their piers. It possesses the great advantages of giving the men a good platform to work upon, and under some conditions may thus prove less costly than other methods where no staging is used. The parts of the work that are being erected are not subjected to any strain, such as often occurs in the other methods, especially in the case of cantilever and girder bridges like that over the Forth, or the arched bridge just built over the Zambesi. Every member is supported by the staging until the last rivet is closed, and each is then subjected only to the normal stress for which it has been proportioned.

Joints. The methods of jointing the heavy timbers for staging admit largely of repetition—that is, the forms used are not very numerous, but they occur again and again. Some of the principal are shown.

It may be laid down as an axiom that the less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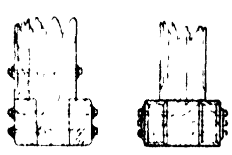
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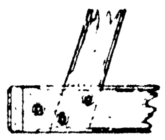
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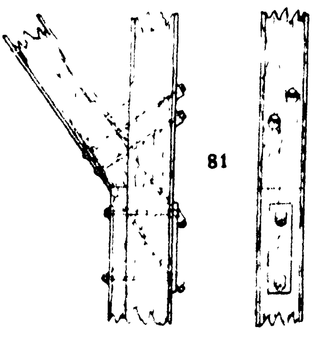
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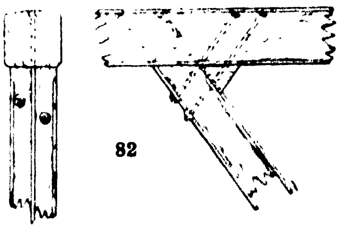
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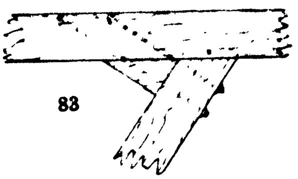
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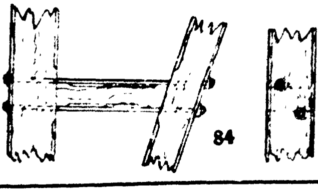
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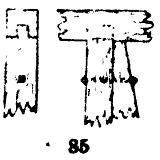
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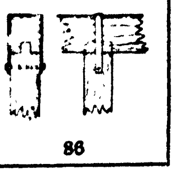
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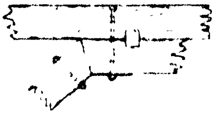
cutting done the better from the point of view both of economy and of strength; economy of time, and also in money, from the fact that the material is more saleable on the conclusion of a contract; strength, because deep cutting diminishes the strength of a section. Still, as *already remarked, it is seldom usual to trust to bolts alone for security, but joggling, even though shallow, is practised. Beams, stringers,* transoms, are notched or joggled, and struts are stub-tenoned. Strap bolts and through bolts figure largely as fastenings. Where these alone are not sufficient, straps *of forms suited to the joints and direction of joints of the beams are* laid against faces and bolted through. Numerous examples are grouped in 78—91. Fig. **78** illustrates the shouldering of an upright between two horizontals. Fig. **79** is similar, with the addition of a diagonal strut, which rests on a horizontal. Fig. **80** is a diagonal timber: a chock fills in the end, and the whole is bonded and bolted together. Fig. **81** is a diagonal strut abutting on a step or straining-piece, and secured by bolts. The long bolts flanking the diagonal go up to horizontal timber. Fig. **82** shows the detail of the other end of the diagonal fastening to the horizontal timber. Fig. **83** is another diagonal fastening made with long bolts. Fig. **84** is an intermediate tie securing a vertical to a diagonal member away from the end fastenings. Fig. **85** shows horizontals and verticals fastened with tenon and bolts, and a diagonal stub-tenoned; **86** is a right-angle fastening, tenoned and bonded with a strap bolted through; **87** shows uprights united to a horizontal with a joggled piece; **88** illustrates strutting attached with an iron knee; **89**, crossing diagonals shouldered into the upright; and **90** and **91** show various crossing joints shouldered and secured with covering straps and bolts. These do not exhaust the joints possible, but scarfed and joggled forms, and the methods of making mortises and tenons, etc., will be given in the course on CARPENTRY. The timber used for staging is usually deal or pitch pine.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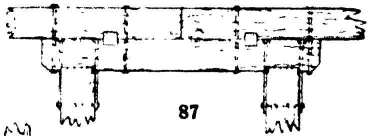
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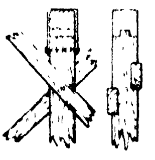
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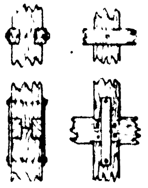
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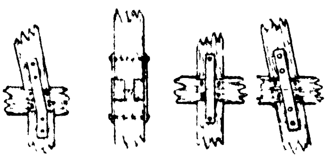
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Gantry Stagings. Gantries and staging for travelling cranes, crabs, erecting towers, and for fixed cranes, are used largely. The principles laid down are embodied in these. There are two principal types—the framed structure and the braced—and both kinds are made fixed or portable. Gantry framings of both kinds are shown with variations in the method of construction.

In the fixed type [**72** and **73**], which may be extended to any length, the work being an exact repetition of that shown, the cheapest style of construction is given. The various members are fastened with dogs. The verticals and horizontals are strutted, and diagonal struts afford stability at the ends [**72**] and sideways [**73**].

In the portable type [**74**], which has to be stable in itself, more care is taken with the joints and fastenings. On such end framings any superstructure can be raised, either timber beams for cranes or floorings. Strutting of these in a *direction at right angles with the plane of the framings must be done, and if the beams are of any considerable length they must be trussed.*

The travelling wheels must have their axles carried in cast-iron bearings bolted to the timbers, and in heavy gantries provision must be made for travelling by toothed gears operated by winch-handles.

Derrick Stagings. When it is necessary to hoist materials to a great height, as in the erection of tall buildings, a derrick crane mounted on a high staging [**71**] is more economical than a gantry with a travelling crane. The kind of stage employed for this purpose consists of three built-up legs, one at each corner of a triangular base. The main one, known as the king leg, supports the derrick. The other two are termed queen or chain legs, and their function is to afford anchorages for the guys of the derrick. These legs each consist of a square column of lattice-work formed by four vertical corner timbers, each of about 12 or 14 in. square, connected by horizontal and diagonal bracings. The king leg has a middle vertical timber, in addition to the corner ones, and is generally of larger dimensions than the queen legs, though all are of the same height. Owing to the great height, the vertical timbers have to be built up, either by fishing balks end to end, or by bolting a number of deals together and arranging them so that they break joint. A secure base of concrete or crossed balks must be prepared to erect this staging on. The legs are connected at the top by trussed girders, and below by diagonal timbers.

The legs are loaded with kentledge, either bricks, stones, or pig-iron. A chain is suspended from the extremities of the derrick legs, and is loaded near the ground. This prevents risk of overturning of the crane, or lifting of the back guys, which in ordinary cranes fixed to the ground is done by bolting them into the sleepers.

Continued

Continued from page 1031

NATURE'S RECORDS OF EVOLUTION

The Story of Evolution Read in Rocks and Animals. Geological Succession of Animals. Theories of Weissmann, Beard, and Reid

By Dr. GERALD LEIGHTON

Geological Periods. The story of the rocks depends upon the fact that the deposits of sand, mud, limestone, and so forth, which are formed are arranged in successive layers, of *which those nearest the surface are the most* recent, unless some upheaval has occurred to alter the arrangement. Any given stratum or layer of rock, together with the fossil remains found in it, is therefore of greater antiquity than those which rest upon it, and of more recent date than those which are found underneath it.

From this fact geologists are able to arrange strata in their order of time, and thus to construct "the geological record." This record constitutes the story of the rocks. The details of it will be found in the course on Geology. We may simply note here that it can be divided into four great periods, which are characterised by fossils of corresponding types. These four periods are as follows:

1. THE KAINOZOIC EPOCH, the youngest of all, corresponding to the age of birds and mammals.
2. THE MESOZOIC EPOCH, corresponding to the age of reptiles.
3. THE PALÆOZOIC EPOCH, corresponding to the age of amphibians, fishes, and invertebrate creatures.
4. THE EOZOIC EPOCH, the age of unknown forms of life.

We ourselves live in the first of these epochs, the Kainozoic, a period which has lasted for a much shorter time than the Mesozoic, the latter in turn being shorter than the Palæozoic. It is quite possible that the Eozoic was longer than all three together. The entire record includes a thickness of stratified rocks of some 100,000 feet.

In order to illustrate the evidence afforded by a study of fossils in favour of organic evolution, we may take the case of one well-known mammal —the horse—and see what is known of the origin of this particular species.

The Evolution of the Horse. The horse may be regarded as one of the "show-pieces" of organic evolution, because a very long series of fossil horse-like creatures has been discovered which prove conclusively the course of events for this particular animal. They tell the gradual origin of the specialised modern horse from the primitive generalised ancestor. They show the relationship of the horse to other creatures, such as the tapir and the rhinoceros, which represent other stages of the horse evolution, a view which is borne out also by the facts of development.

The ancestors of the modern horse are represented in the geological deposits of both Europe and America, those of the New World being wonderfully complete. These remains are found in the tertiary rocks, the divisions of which are termed respectively *Pleistocene*, *Pliocene*, *Miocene* and *Eocene*, the last being the oldest and the first the newest of this series [see GEOLOGY]. The series is thus described by G. P. Mudge in his "Text-book of Zoology":

Fossil Horses. "The first fossil remains of the horse in America are found in the deposits of the *Upper Pliocene*, and they are in no way different from the corresponding portions in the recent horse, which is an animal whose limbs have become modified in accordance with the requirements of the rapidity of flight over undulating plains and a firm ground. Both the fore and hind limbs of the horse possess only one digit (third finger and toe respectively) and two splint bones, one on either side of the functional digit, which correspond in position to the bones of the middle hand or foot respectively.

"In the *Middle Pliocene*, the remains of an animal (*Pliohippus*) slightly smaller than the horse, and possessing its small hooflets, is found; farther down in the *Lower Pliocene*, an animal about as large as the ass, called *Protohippus*, is found, whose fore and hind limbs both possess three fingers and toes respectively, but only the middle one is functional and reaches the ground. Earlier still, in the *Upper Miocene*, *Miohippus*, of slightly larger stature than a sheep, is found, whose limbs possess three functionally developed digits and a small splint bone on the fore limbs; in the *Lower Miocene*, a smaller animal, *Mesohippus*, has the same three functional digits, but the splint bone is much larger. In the *Upper Eocene*, *Orohippus*, has four digits, or toes, of which only three reach the ground, the smaller one corresponding in position to the splint bone of *Mesohippus*. In the early *Eocene* *Eohippus*, with four functional digits and a remnant of a fifth, is found.

"As we search backwards through the record of the rocks, we can thus trace the successive stages by which the one-toed and one-fingered horse has been derived from a five-toed and five-fingered ancestor; and a comparison of the horse's limb with those of the animals mentioned above shows that the two splint bones correspond to the second and fourth digits, and the functional toe to the third one of the pentadactyl limb of the horse's ancestor."

How the Horse was Evolved. In the European rocks the record is not so complete, but is on precisely the same lines. The earliest form known has three functional toes—that is, three toes which reach the ground; a later form is found in which the two side digits are not functional, they do not reach the ground, but the middle one has become more prominent; and in a still later form this condition is accentuated. So that by the gradual disappearance of the outer fingers and toes, the present condition of the limb of the horse, that of having only one functional finger and toe, is reached.

It must not be imagined from these interesting discoveries that we have here a direct line of descent before us, or that one of these ancestral forms gave rise directly to the next known. The record is of necessity imperfect, and will doubtless receive many additions in future. Moreover, as we have seen, large groups of animals have disappeared without leaving us any trace hitherto discovered, the condition necessary for their preservation being absent.

We must not expect more than is reasonable from the nature of the case. Minute connecting links are doubtless lost for ever in the processes of decay. If we can find one variation here and there which points the way, it is as much as is to be expected. But the facts we have mentioned appear to admit of no other interpretation than that afforded by the theory of organic evolution, and the scientific imagination can readily picture the environments which accompanied the successive stages. The evidences of geology come to our assistance, and enable us to form some such picture of events as the following.

The Past Reconstructed. "The Eocene period, which was peopled among others by the tribe of the Eohippi, was a period of great geological unrest; great land masses were slowly sinking beneath the sea, and some of the great Alpine chain of mountains of the present day were being formed beneath the ocean, while others were in course of elevation above the sea-level. These elevations and subsidences were not sudden and cataclysmic, but occupied hundreds of thousands of years. There is evidence to show that the greater portion of Europe, and a large part of America, were at this period beneath the surface of the sea, or but little above it.

"The physical conditions of such a period must have been characterised by the presence of extensive marshy swamps, with here and there eminences of dry land. Under these swampy conditions of the ground, *Eohippus*, with its wide tetradactyl (*i.e.*, four digits) and the then but recently pentadactyl (*i.e.*, five digits) hand and foot, was favourably adapted, for it could move, if but slowly, at any rate with security.

Birth of a New Tribe. "In the latter part of the Eocene epoch the elevation of the ground was still proceeding, and much of it had become drier and firmer; during the same time there had appeared among the Eohippi stock certain individuals in which a spontaneous variation had appeared in the form of a less well-developed fourth toe (*Orohippus*). We know that a spontaneous variation of this kind is hereditarily transmitted, and that if both parents possess it the variation in the offspring is accentuated.

"Now, we may imagine, for there is nothing improbable or inconsistent with known facts in so doing, that such a favourable sexual union occurred, or, for the matter of that, that several did so. There would thus arise a progeny with strong innate and congenital tendency to a reduction of the fourth toe, and this progeny would interbreed and the variation become still more accentuated, until only a splint-bone (*metatarsal*) of the fourth toe was left. Thus would arise the tribe of Mesohippi.

"If we suppose that this variation in the direction of the loss of digits conferred any advantage upon the individual beyond that possessed by those in which such variation had not appeared, that, for instance, in the struggle for existence resulting from the tendency of animals to reproduce beyond the means of subsistence, a three-toed animal could move more quickly than a four-toed one, it would more easily obtain its food and have better chances of surviving and procreating its species than its less favourably adapted fellow.

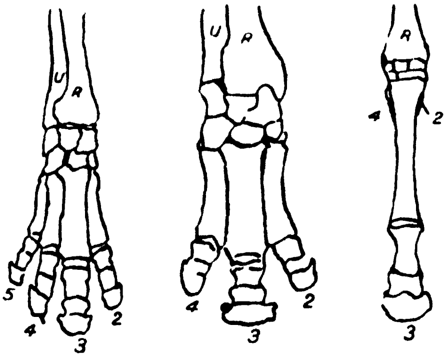
Variation to Suit New Conditions. "And this in reality must have happened; for, as the land gradually rose higher above the surface of the sea, the swampy areas favourable to the four-toed Eohippi would become more and more limited and the food supply therefore less, while the dry and firm areas would correspondingly increase and the food material which it could produce. And those forms which were best adapted to move over firm and dry ground would have more chances of surviving and reproducing their species than those which were only adapted for marshy swamps.

"In connection with this greater rapidity of motion, it must be remembered that the loss of toes was correlated with increase in the length of the limbs, in size of body, and alteration of the pattern of the teeth. All the swiftly moving ungulate animals of to-day are either single-toed, like the horse, or double-toed, like the deer; and for mechanical purposes the double-toed forms are really single-toed, for the two metacarpals of the fore limb and metatarsals of the hind limb are fused together in most instances." (Mudge.)

So, according to this view, the horse has been evolved from a primitive five-toed and five-fingered ancestor by the natural selection of spontaneous variations in the digits, variations which gave their possessors the advantage in the struggle for existence in their changing environment, particularly in the matter of obtaining food. This is the essence of the theory simultaneously announced by Darwin and Wallace, and the horse is one of the best examples of it which can be quoted.

Theory and Fact. Looking at the matter altogether apart from the theory of Darwinism, the actual specimens of these variations are found and can be seen. Successive forms showing all the differences mentioned between the five and one toed animal have existed, and no other reasonable explanation is forthcoming, except that these represent stages in the gradual evolution of the horse as we see it at the present time.

Additional Evidence. There is still another point which the case of the horse illustrates well. We know that modern species occasionally produce offspring which vary in the direction of their ancestors. They "throw back," in popular language; they exhibit "atavism," in technical terms. Does such a thing ever occur in horses? It does, in a most interesting manner. Horses have been met with which possessed toes corresponding to the form known as Hipparion, the two splint-bones having their corresponding digits. Still more commonly, we find the modern horse developing an extra tooth in front of the premolars, this tooth being known as the "wolf's tooth." Now, a normal modern horse does not possess this tooth, but it occurs constantly in one of the early European fossils, and as often as not in Hipparion. Such structures when they occur in modern individuals are termed "vestigial structures"; they represent structures which were once constant, but are now no longer existent, or are in actual course of disappearance. They form important additional evidences of the course of organic evolution. They cannot be accounted for upon any other supposition.



Tapir Rhinoceros Horse

VARIATIONS IN THE FORE FEET OF ANIMALS

U. Ulna R. Radius, 2, 3, 4, 5, respective digits

The Rhinoceros and Tapir. It is interesting to note that in some existing animals these variations of the limb are still to be seen. In the rhinoceros the second, third, and fourth digits on each foot are still retained. The reduction has not gone on to the stage of the horse. The rhinoceros remains three-toed. Professor Cossar Ewart has shown that in the unborn foal these second and fourth digits are represented by small projections on each side of the limb. Another variation is that seen in that most curious animal the tapir, a creature somewhat like a pig in general appearance but with a short proboscis. It dwells only in South America and the Malay region. Geological evidence shows that similar animals once existed in North America, Europe, and Asia, and this fact in itself is to be explained only by the theory of organic evolution, extinction having occurred in the intervening areas in the struggle for existence. The condition of the foot of the tapir, represented in the illustration (together with that of the horse and the rhinoceros), is that the fore limb possesses four digits, while the hind limb has only three. It is the comparative structure of the limbs, as represented by the presence or absence of digits, upon which we desire to lay special stress at this point. No other explanation but that afforded by the theory of organic evolution can explain the existence to-day of a creature having limbs made like those of the tapir.

The Geological Succession of Animals. We may here conveniently summarise the geological evidence of this matter, mentally resolving to learn more of this aspect of evolution from text-books especially devoted to the subject.

Fossil animal remains teach that the earlier the fossils the less are they like animals now on earth; the later the fossils the more nearly do they approximate to the species as now seen. The oldest fossils are those of the invertebrates, with a few fish. Many of these are generalised types as opposed to what we term specialised types. The more generalised types have disappeared in the struggle for existence, except in a few isolated cases, such as the tapir, one of the most generalised mammals existing. The succession of forms which point to the ancestry of the horse finds a parallel in the sea-urchins and ammonites, the older of which are more generalised, the latter having more special and elaborate structures. In the amphibians and reptiles those parts of the animals which are most used have undergone most elaborate specialisation from the ancient types, the specialisation being most marked in the more recent forms. In Palaeozoic times a large number of creatures existed which belonged to types which would now be quite useless in the present struggle for existence. They were extinguished, suddenly or gradually, by natural agencies, only the advantageous variations surviving. Nature has, throughout the ages which are gone, evolved by the agency of her own laws species of plants and animals best fitted for the changing environments. On the whole there has been progress, the best proof of which is the evolution of man himself.

We have now taken a general view of the problem of organic evolution, and examined the two great theories of the last century which attempted to account for the facts, with the result that we find ourselves more in accordance with the view advanced by Darwin and his followers than the older theory of Lamarck. But we at the same time freely admit that the last word concerning the origin of species was not said by Darwin, and that since he wrote a very great deal has been learnt which may very well modify the conclusions to which he came. Nevertheless, speaking broadly, all the evidence is on that side, and all the more recent views which have been advanced do not really contradict the essence of Darwinism, but rather strengthen its weak places. They all proceed from Darwin's foundation—*viz.*, the universal prevalence of variations of a spontaneous nature which can be transmitted by heredity, and which are in some way selected. Now, it is quite true that Darwin and Wallace used the term "Natural Selection" in a definite manner, in the sense in which we have used it in this course, and it follows that any other kind of selection is not, strictly speaking, Darwinian. What we wish to emphasise is that the later views are the lineal descendants of Darwinism, and bear upon their faces the imprint of their origin. They seek to answer some of the objections and difficulties which have been urged against natural selection as propounded by Darwin, to supply what many have thought was still required in order to account for all the facts. Of these quite recent views there are four which we must mention briefly in order to indicate the trend of thought at the actual moment of writing, and to prepare us for developments in the immediate future.

Weismann's Theory. Professor Weismann, of Freiburg, perceiving the difficulties of the natural selection theory, and having no faith at all in the other views, formulated a theory of selection which is termed "Germinal Selection." The essence of this law is that the struggle for nutrition—that is to say, the real struggle for existence—takes place in the germ-plasm itself before the development of the embryo. The germ is supposed to contain certain definite portions which give rise to corresponding parts of the developed body. If one of these germ-portions ("determinants," he terms them) is vanquished in the struggle for nourishment, it grows weaker than other parts which are better nourished, and gives rise to a minus variation —a negative variation—in the individual, who thus perishes because of the survival of those in whom this part is strong. Owing to the continuity of the germ-plasm, the process of weakening goes on with added force in successive generations, until at last that special portion of germ-plasm perishes, and the part which it represents therefore disappears from individuals.

We need only say here that this is pure theory, a mental conception to account for some observed facts. There is no actual evidence in existence to show that such things as "determinants" are in the germ-plasm. The theory is bound up with the theory of heredity put forward by Weismann, to which we shall refer later.

Dr. Beard's Theory. Dr. Beard also maintains a theory of "Germinal Selection." He believes that in sexual reproduction the whole number of characters of the two parents are mingled up to a certain point, just as the cards in two different packs might be mingled by shuffling them together. There will thus be in every fertilised germ-cell two representatives of each character or quality. At a certain stage after fertilisation one representative of each character or quality is eliminated or suppressed, the one to be preserved being that best suited to the environment of the germ-cell. According to Dr. Beard, selection occurs within the germ-cells, and there is a selection of germ-cells; he maintains, too, that this form of germinal selection is a much more potent factor in adapting species to the environment in which they find themselves than is the natural selection propounded by Darwin. "What it (*i.e.*, natural selection) would do, that, and far more than that, Nature brings about in a more efficient way by selecting in the germ-cell which of two characters or qualities, the greater or lesser, shall be taken." Dr. Beard believes that the environment of the germ-plasm is such that it selects portions of germ-plasm representing characters in a manner similar to, but more certain than, the way in which Darwin supposed individuals to be selected. Darwin would eliminate the unfit individuals in the struggle for existence. Dr. Beard would eliminate the unfit germ-cells. He attributes the variations to the action of the environment, to every part of which the germ-cells will react. Those which react favourably are selected, those which react unfavourably will diminish.

Dr. Archdall Reid's View. Archdall Reid, the well-known writer on evolution and heredity, also seeks to supply the unknown factor in organic evolution. He maintains that not only is there one great force at work in Nature—namely, Natural Selection—but that in addition there is another—namely, Reversion. "The former causes progressive evolution, the latter regressive evolution. They are opposed, but one would be quite inadequate without the other. They are warring forces, but their resultant is a near approach to perfection. Between them they tend to bring every species into exquisite harmony with its environment." "A variation may be progressive or regressive in type. A progressive variation constitutes a deviation from the parental *and* ancestral type, which, speaking generally, is in the direction of increased magnitude and complexity. It results from the complete recapitulation of the parental development *plus* an addition. A regressive variation constitutes a deviation from the parental *towards* the ancestral type. As a rule it is in the direction of diminished magnitude or complexity. It results from an incomplete recapitulation of the parental development. . . . Evolution is *adaptive* racial change. . . . The tendency to vary spontaneously has been evolved by Natural Selection. . . . Only inborn characters are transmissible to offspring. Evolution, therefore, proceeds solely on lines of inborn characters. Every individual in his development follows (with variations) in the footsteps of his predecessors. The development of every individual is, therefore, a recapitulation (with inaccuracies, with omissions and additions) of the life-history of his race. Since regressive variations tend to be of greater magnitude and prepotency than progressive variations, the tendency to regression is always greater than the tendency to progression. Consequently, progressive evolution can occur only when selection is somewhat stringent, and this is especially the case when a character has been recently and quickly evolved. It follows that, whenever the stringency of selection is relaxed, a character which has undergone evolution tends to regress. During the evolution of the species many parts become useless. Natural selection, therefore, has evolved bi-parental reproduction, which regulates the tendency to reversion in a very beautiful, effective, and discriminating manner. It aids natural selection to preserve structures and variations when they are useful, and assists regression to eliminate them when they are useless. . . . Natural selection seizing on progressive variations causes progressive evolution. Bi-parental reproduction seizing on regressive variations causes regressive evolution. The latter is a necessary accompaniment of the former. Natural selection, as commonly understood, therefore, explains only half the facts of evolution. The environment acting on, or through, the parent, has little or no effect on offspring subsequently born. . . . Evolution is due solely to natural selection. But besides the simple and direct elimination of the unfittest which Darwin describes, species are adapted to their environments by other means more subtle and exact." These brief extracts from Dr. Reid's book on "The Principles of Heredity" will serve to indicate his main contentions, and the work itself must be consulted for the arguments adduced in their support.

The Origin of Species by Mutations. We have left to the last the mention of a theory of organic evolution which, advanced only a year or two ago by De Vries, is rapidly assuming a very prominent place in the minds and beliefs of modern biologists. Like other modern views, it has a distinct flavour of Darwinism about it, but at the same time it has its own distinctive idea. It will be remembered that Darwin thought that plants and animals had evolved into species and varieties by a very slow and gradual process as a rule, this process depending upon the selection of somewhat *small and minute variations* which were accumulated by selection. Darwin's theory demands great periods of time for its accomplishment. He thought that very gradual change was the rule.

De Vries, on the other hand, has propounded the somewhat startling proposition that evolution in plants and animals is by no means so slow and gradual as was supposed, and that instead of species arising by the selection of small advantageous variations, they are often produced *suddenly* by large and very marked variations, which are transmitted to offspring and which breed true. According to this view the enormous periods of time demanded by the Darwinian theory are not required, and it accounts for the sudden appearance of species without any series of connecting links with others. These large variations, which De Vries believes give rise to new species, he terms "mutations," to distinguish them from the smaller modifications or "variations" of the older view. Of all the views put forward since Darwin's, this is the most far-reaching. It threatens a revolution in biological thought almost as great as that which followed the enunciation of Darwinism.

Evidences for the Mutation Theory. De Vries has proved experimentally that these large variations frequently occur, and, more than that, he has proved that they breed true to themselves. In other words, he has shown that their origin is in the germ-plasm and not in the body, or soma. His theory does not involve a belief in the transmission of acquirements, since he deals with germinal, not somatic, variations. Like Darwin, he depends upon natural selection for the mode of operation. Darwin based his theory largely on the practice of breeders in selecting artificially. De Vries shows that this artificial selection depends largely, if not entirely, on the selection of these *large* variations, or "mutations," and his view is confirmed by experiments made in this country by Hurst, who has used rabbits and plants for this purpose. The opinion is gradually gaining ground that organic evolution is in the main due to these mutations rather than to small variations.

It is only right to add that Bateson, of Cambridge, was the first to point out the importance of these "discontinuous variations" which De Vries terms "mutations." The existence of them was noted by Darwin, but he regarded them as of comparatively little importance, as those known to him were chiefly monstrosities. Since that time we have learnt a great deal more about their nature and frequency of occurrence.

It is never safe to prophesy, but we venture to think that in the future the origin of new species by mutations will be recognised as a most important, if not *the* most important, method of organic evolution.

Continued

Group 18

LANGUAGES

8

Continued from page 1056

LATIN—ENGLISH—FRENCH—GERMAN

Latin and English by G. K. Hibbert, M.A.; French by Louis A. Barbé, B.A.; German by P. G. Konody and Dr. Osten

LATIN

Continued from page 1049

By Gerald K. Hibbert, M.A.

SECTION I. GRAMMAR

Irregular Verbs : Second Conjugation

The most important exceptions to the regular formation of *-ui* and *-itum* are :

Perfect *-vi*, Supine *-tum*

deleo	delēre	delevi	deletum	*blot out*

(So also *Fleo* = weep, and *-pleo* = fill.)

Perfect *-ui*, Supine *-tum*.

doceo	docēre	docui	doctum	*teach*
misceo	miscēre	miscui	mistum	*mix*
teneo	tenēre	tenui	tentum	*hold*

Perfect *-si*, Supine *-tum*.

augeo	augēre	auxi	auctum	*increase*
torqueo	torquēre	torsi	tortum	*twist*
lugeo	lugēre	luxi	—	*mourn*

Perfect *-si*, Supine *-sum*.

mulceo	mulcēre	mulsi	mulsum	*soothe*

Similarly, *ardeo* (take fire), *rideo* (laugh), *suadeo* (advise), *maneo* (remain), *jubeo* (order, perf. jussi), *hæreo* (stick), *fulgeo* (glitter).

Perfect *reduplicates*, Supine *-sum*.

mordeo	-ēre	momordi	morsum	*bite*
pendeo	-ēre	pependi	pensum	*hang*
spondeo	-ēre	spopondi	sponsum	*pledge*
tondeo	-ēre	totondi	tonsum	*shear*

Perfect *-i*, Supine *-sum*.

prandeo,	-ēre	prandi	pransum	*dine*
sedeo,	-ēre	sedi	sessum	*sit*
video,	-ēre	vidi	visum	*see*

Perfect *-i*, Supine *-tum*.

caveo,	-ēre	cavi	cautum	*beware*
faveo,	-ēre	favi	fautum	*favour*
foveo,	-ēre	fovi	fotum	*cherish*
moveo,	-ēre	movi	motum	*move*
voveo,	-ēre	vovi	votum	*vow*

[Notice that most of our English nouns are derived from Supines—*e.g.*, torture, tonsure, vision, session, etc.]

Also three deponents :

fateor	fatēri	fassus	*confess*
misereor	miserēri	misertus *or* miseritus	*have pity on*
reor	rēri	ratus	*think*

The Roman Calendar

Names of the Roman months (all adjectives) :

Januarius, a, um
Februarius, a, um
Martius, a, um
Aprilis, e
Maius, a, um
Junius, a, um
Quintilis, e (*or* Julius)
Sextilis, e (*or* Augustus)
September, bris, bre
October, bris, bre
November, bris, bre
December, bris, bre

[The year originally began with March ; therefore, July was the fifth, September the seventh month, and so on. *Quintilis* and *Sextilis* were later called *Julius* and *Augustus* in honour of Julius Cæsar and the Emperor Augustus.]

Every Roman month had three chief days : *Kalendæ, -arum* (Calends) ; *Nonæ, -arum* (*Nones*), *Idūs, Iduum* (Ides) : all three feminine. The Calends were always on the 1st ; the Nones usually on the 5th, and the Ides usually on the 13th. But in March, May, July, and October, the Nones and Ides were two days later—*i.e.*, on the 7th and 15th respectively.

From these days the Romans counted *backwards*, the days between the 1st and the Nones being reckoned as so many days before the Nones ; the days between Nones and Ides, as so many days before the Ides ; and the remaining days of the month as so many days before the Calends of the next month.

1. When the date falls on one of the three chief days, the date is put in the abl., the month, of course, agreeing with the noun

Jan. 1st *Kalendis Januariis.*
March 15th. *Idibus Martiis.*
Nov. 5th. *Nonis Novembribus.*

2. The day immediately preceding any of these three reckoning points was called "pridie" (*i.e.*, priore die), followed by the acc.

Jan. 31st. *Pridie Kalendas Februarias.*
Apl. 12th. *Pridie Idus Apriles.*
Oct. 6th. *Pridie Nonas Octobres.*

3. In any other date, we find out how many days it is before the next Calends, Nones, or Ides, (remembering to count in both the date in question *and* the Calends, etc.). Thus, Jan. 30th is the *third* day before the Februarian Calends, and would be in Latin *ante diem tertium Kalendas Februarias.*

Further examples :

Dec. 2nd. *Ante diem quartum Nonas Decembres.*

March 16th. *a.d. septimum decimum kalendas Apriles.*

These are usually written "a.d. IV. Non. Dec.," and "a.d. XVII. Kal. Ap.," and so with the others. The original signification of this expression seems to have been "before (on the fourth day) the Nones of December," the exact day being thrown in parenthetically, and attracted from abl. to acc. in consequence of following "ante."

4. In Leap Year, Feb. 24th (a.d. VI. Kal. Mart.) was reckoned twice, hence this day was called *dies bissextus*, and leap year itself, *annus bissextilis*.

SECTION II. COMPOSITION.

The Subjunctive Mood. This is one of the most difficult subjects in Latin. English usage gives no guidance, and, in fact, the subj. is as common in Latin as it is rare in English. In the following sentences, for example, the words in italics would be in the subj. mood in Latin: "It was so cold that the water *froze*" (consecutive after *ut*). "I asked why he *did* this?" (indirect question). "I fear that you *are* ill." "He said that the man who *did* this should die" (dependent verb in Oratio Obliqua). "There is no doubt that twice two *are* four." Roughly, we may say that the indicative indicates a fact, while the subj. expresses "something which we regard rather as a mere conception of the mind, as that which we purpose or wish to be a fact, or to which we refer as the result of another fact, or as stated on other authority than our own."

Usually, the subjunctive is used in certain classes of subordinate or *subjoined* clauses. But it is also used both in simple sentences and in the main clause of a compound sentence in the following cases:

1. To make a statement in a hesitating manner, sometimes called the potential mood. This is strictly a hypothetical subj. with the condition not formally expressed.

Hoc dicere ausim = I would dare to say this (if I were allowed).

Vix crediderim = I can hardly believe.

Hoc facias velim I would have you do this ("ut" understood with "facias").

2. To ask a question, rhetorically, not for information; sometimes called dubitative questions. Usually a negative answer is expected.

Quis credat? = who would believe?

Quid ego facerem = what was I to do?

3. To express a wish or desire (optative or jussive), often with *utinam* (= would that!). Negative *ne*.

Utinam adjuvisset = would he had been present!

Di Carthaginem deleant = may the gods destroy Carthage.

Ne transieris Iberum = do not cross the Ebro. (In negative commands, use the perf. subj., not the imperative. Or else say *noli transire* = be unwilling to cross.)

Only in these classes of sentences is the subj. found in simple or principal sentences. In all the rest it is in subordinate sentences. Including those given above, there are eight main uses of the subj. mood:

1. Hypothetical: see No. 1 above. In these sentences the protasis (*i.e.*, the *if* clause of a conditional sentence) is suppressed.

2. Conditional—*e.g.*, *Si jussisses* (protasis), *fecissem* (apodosis) = if you had bidden, I should have done it. *Si adsis, facturus sum* = if you should be there, I mean to do it.

3. Optative, jussive, or concessive (see No. 3 above). "The imperative is the language of an absolute master: the subj. is a suggestion to an equal or superior."

• In concessive sentences, a person rhetorically commands or supposes a change of what he knows or believes to be the fact.

4. Final, expressing purpose (negative *ne*).

(*a*) In adjectival sentences: *Dignus est qui vincat* = he is worthy to conquer. *Mitto qui dicat* = I send someone to say.

(*b*) In sentences introduced by *ut* (in order that), *ne*, *quo*, *quominus*, *quin*: *Ede ut vivas* = eat that you may live. *Non vixit ut ederet* he did not live to eat.

(*c*) In sentences of time or condition, with *dum*, *dummodo*, *donec*, *priusquam*, etc. *Oderint dum metuant* = let them hate provided they fear.

5. Consecutive, expressing result; usually with *ut* so that (negative, *ut non*): *Tam debilis sum ut non ambulare possim* I am so feeble that I cannot walk. *Is sum qui illud faciam* = I am the man to do that.

6. Subj. of attendant circumstances: *Quæ quum ita sint, hoc dico* under these circumstances (lit. since which things are so), I say this. *Peccavisse videor qui illud fecerim* I seem to have sinned inasmuch as I have done that.

7. Subj. of reported statements, comprising sentences of definitions, reasons, and questions, which are given *not as the speaker's own*, but as someone else's.

Contrast "Laudat puerum quod *fuit* abstinens" (the reason alleged being given on the speaker's own authority) with "Laudat puerum quod *fuerit* abstinens" (the reason being a reported or assumed one, "He praises the boy, because he understands the boy to be abstemious").

8. Subj. because dependent on another subj. or infinitive. In all such sentences the subjunctive simply prevents the speaker from being supposed to be responsible for the statements, etc., reported, or to be giving them as independent assertions. To this head, of course, belongs the subj. in Oratio Obliqua. Examples:

(*a*) Depending on infinitive:

Dicit eos qui boni essent beatos esse (he says that those who are good are happy).

(*b*) Depending on another subjunctive:

Petit ut iis qui adfuerint credamus (he asks that we should believe those who were present). In such a case as this it is often said that *adfuerint* is *attracted* into the subj. by *credamus*.

TO BE TURNED INTO LATIN PROSE.

THE FUNERAL OF OLIVER CROMWELL.

BY ABRAHAM COWLEY.

It was the funeral-day of the late man who made himself to be called Protector. And though I bore but little affection, either to the memory of him, or to the trouble and folly of all public pageantry, yet I was forced by the importunity of my company to go along with them, and be a spectator of that solemnity, the expectation of which had been so great that it was said to have brought some very curious persons and no doubt singular virtuosos) as far as from the mount in Cornwall and from the Orcades. I found there had been much more cost bestowed, than either the dead man, or indeed death itself, would deserve. There was a mighty train of black assistants, among which, too, divers princes in the persons of their ambassadors (being nfinitely afflicted for the loss of their brother) were pleased to attend ; the hearse was magnificent, the idol crowned, and (not to mention all other ceremonies which are practised at royal nterments, and therefore by no means could be omitted here) the vast multitude of spectators made up, as it uses to do, no small part of the spectacle itself.

LATIN VERSION OF THE ABOVE.

Dies erat quo inferebantur tumulo reliquiæ illius qui Protectoris nomen occupaverat. Me,[5] quamvis[6] neque[7] viri[11] memoriæ[10] neque[12] operosæ[13] publicarum[15] sollemnitatum[16] vanitatis[14] admodum[8] studiosum[9], perpulere[4] tamen[3] sociorum[2] preces[1] ut cum iis spectarem pompam illam, quæ tam cupide jamdudum fuerat expectata, ut nonnulli curiosiores, limatissimo nimirum ingenio homines, usque a monte apud Cornubios et ab Orcadibus insulis *visendi causâ** in urbem progressi essent. Intellexi multo plus in funus erogatum esse quam pro mortui meritis, immo pro mortis ipsius dignitate. Ingens pulatorum ordo, assistentibus etiam quibusdam legatis, qui regum personas fratrem summo studio desiderantium sustinerent : feretrum splendidissimum ; coronata effigies ; denique, ne omnia alia commemorem quæ, utpote in regum funeribus sollemnia, hic nullo modo omitti poterant, pars haud exigua spectaculi fuit, ut fit, vasta spectantium multitudo. (J. Conington.)

SECTION III. TRANSLATION.

A LETTER FROM CICERO TO HIS FRIEND ATTICUS. WRITTEN IN MARCH, B.C. 46 :

Undecimo die postquam a te discesseram, hoc litterularum exaravi egrediens e villa ante lucem, atque eo die cogitabam in Anagnino, postero autem in Tusculano ; ibi unum diem. V. Kalend. igitur ad constitutum ; atque utinam continuo ad complexum meæ Tulliæ, ad oscuum Atticæ possim currere ! quod quidem ipsum scribe, quæso, ad me, ut, dum consisto in Tusculano, sciam quid garriat, sin rusticatur, quid scribat ad te, eique interea aut scribes salutem aut nuntiabis, itemque Piliæ. Et tamen, etsi continuo congressuri sumus, scribes ad me, si quid habebis.

Cum complicarem hanc epistolam, noctuabundus ad me venit cum epistola tua tabellarius, qua lecta de Atticæ febricula scilicet valde dolui. Reliqua, quæ exspectabam, ex tuis litteris cognovi omnia ; sed quod scribis " igniculum matutinum gerontikon " (a Greek adjective, meaning " characteristic of an old man "), gerontikoteron (comparative) est memoriola vacillare : ego enim IV. Kal. Axio dederam, tibi III., Quinto, quo die venissem, id est prid. Kal. Hoc igitur habebis, novi nihil. Quid ergo opus erat epistola ? Quid ? cum coram sumus et garrimus quicquid in buccam ? Est profecto quiddam " lesche " (gossip), quæ habet, etiam si nihil subest, collocutione ipsa suavitatem.

ENGLISH VERSION OF ABOVE.

Eleven days after leaving you, I am scrawling this bit of a note as I am starting from my country-house before dawn. I think of being at my villa at Anagnia to-day, and Tusculum to-morrow. Only one day there, so I shall turn up to time on the 28th, and, oh that I could run on at once to embrace my Tullia and give Attica a kiss ! As to this very thing, do write me, I beg you, that while I am stopping at Tusculum I may know what she is prattling, or, if she is in the country, what she writes to you about. Meanwhile, either send or give her my love, and also to Pilia. Yet even though we shall meet immediately, write to me if you have anything to say.

P.S. When I was fastening up this letter, your courier reached me after travelling all night with your letter. I am very sorry, you may be sure, to hear, on reading it, about Attica's fever. All the other news I was waiting for I now know from your letter, but when you write that " to want a little fire in the morning is a sign of old age," I retort " it is a surer sign of old age that one's poor memory should falter." For I had intended to spend the 29th with Axius, the 30th with you, and the 31st with Quintus. So take that for yourself : you shall get no news. Then why write, you say ? And, pray, what is the use of our chattering when we are together and saying whatever comes to our tongues ? Surely there is something in a good gossip after all : for even if there is nothing in it, the very act of our talking together has a charm of its own.

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* *Causâ* is an abl. -- for the sake (or purpose) of ; it follows the word which it governs. Here translate " for the purpose of seeing."

Continued

ENGLISH

Continued from page 1032

By Gerald K. Hibbert, M.A.

ADVERBS

Just as adjectives qualify nouns, so adverbs modify or limit verbs—as, " Agag came unto him *delicately*." " He gives *twice* who gives *quickly*." This usage has been extended, and adverbs can now modify adjectives and other adverbs in addition to verbs, as: " Too many cooks spoil the broth " (*too* modifying the adjective *many*). " He struck me *very* forcibly " (one adverb *very* modifying another, *forcibly*).

Adverbs, like adjectives (from which they are mostly formed), are usually classified according to their meaning: just as we divided adjectives into Qualitative, Quantitative, and Relational, so we can divide adverbs. Thus:

1. ADVERBS OF QUALITY: *Well, ill, badly,* and all the adverbs in *-ly* derived from adjectives: *how, however, so, as, likewise,* etc. (sometimes called Adverbs of Manner).

2. ADVERBS OF QUANTITY:

a. Degree: *Very, nearly, almost, too, quite, enough, rather, much, more, most, little, less, least, only, but, just, even, any, the* (as in "*the* more *the* merrier"). Also the adverbs of Affirmation and Negation: *Not, no, nay, aye, yea, yes.*

b. Repetition of Time—as, *once, twice, thrice, often, seldom, always,* etc.

3. ADVERBS OF RELATION, showing

a. Time: *Now, then, after, before, soon, ago, instantly,* etc.

b. Place and Arrangement: *Firstly, secondly, thirdly, here, there, hither, thither, hence, thence, inside, outside, up, down,* etc.

c. Cause and Consequence: *Why, therefore, wherefore, accordingly, consequently,* etc.

It will be noticed that some of the words appearing in this list of adverbs have previously appeared as other parts of speech. *As,* for example, was included under Relative Pronouns; and *much, little, no, any,* were included under adjectives. To determine what part of speech a word is in a given sentence, we must consider the purpose it serves. Thus, "This is the same *as* that" (relative pronoun = "This is the same which that is"); "*As* he went out, he wept bitterly" (adverb denoting the time of the action). Again, "Give him *no* peace" (adjective), "This is *no* better than that" (adverb). Similarly, *much, little,* and *any* before comparatives are adverbs.

Formation of Adverbs. 1. From Adjectives. Most adverbs are formed by adding *-ly* to the corresponding adjective—*e.g., wild, wildly; cheerful, cheerfully.* The termination *-ly* (= like), is the Anglo-Saxon termination *-lic* (adjective), *lice* (adverb).

Adjectives ending in *y* preceded by a consonant change *y* into *i* before *ly*—*e.g., hearty, heartily; speedy, speedily. Shy* is an exception, making *shyly,* not *shily.* The adjective *gay,* which should strictly have *gayly* as its adverb, now usually makes *gaily.*

Adjectives ending in *-le* change the *e* into *y*—*e.g., noble, nobly; horrible, horribly.* When the adjective already ends in *-ly* the same form is generally used for the adverb—*e.g.,* the adverb of *godly* is usually *godly* ("We should live soberly, righteously and *godly* in this present world," Titus ii. 12), though *godlily* is sometimes used nowadays. So also *likely*: "a likely story" (adjective); "he will very *likely* come (adverb). Other adverbs derived from adjectives are *once, twice, thrice* (for *ones, twyes, thries*), *unawares, flatlong.* Some adjectives, in addition to those ending in *-ly,* are used as adverbs without any change of form—*e.g.,* "run *fast,*" "stand *firm,*" "strike *deep,*" "*pretty* good," "Think not so *slight* of glory" (Milton).

2. From Nouns. *Needs* (as in "If I must needs glory"), *whiles, sideways, lengthways, straightways, noways,* are genitive cases of nouns. *Whilom* ("at whiles," "formerly") and *seldom* are dative cases plural of *hwil* (= space of time), and *seld* (= rare). Other adverbs derived from nouns are *headlong, sidelong, piecemeal* (mael = part), *inchmeal* ("All the infections that the sun sucks up . . . on Prosper fall, and make him by *inch-meal* a disease!"—*Tempest*), *limb-meal* ("O that I had her here to tear her *limb-meal*"—*Cymbeline*), *sometimes, always, perhaps, otherwise, midway,* etc. Many adverbs are compounds of the preposition *a* (meaning *on*) and a noun, as *afoot, abreast, aside, asleep;* while some are compounds of other prepositions with nouns, as *betimes* (by times), *besides, indeed.*

3. From Pronouns. *Thus, then, than; here, hither, hence; there, thither, thence; where, whither, whence; why, how* (for *whow*), and all the other adverbs formed from the Relative Pronouns, such as *wherefore, whereat, wherein, whereby,* etc.

These adverbs, that are derived from the Relative Pronouns (with the addition of *as* and *in*), are *Connective* or *Conjunctive* adverbs; that is, they retain the connective power which we have seen belong to Relative Pronouns. A Connective adverb introduces a subordinate clause, and modifies the predicate of this clause. There is always an antecedent expressed or understood in the principal sentence: thus, "He fell full length, *whereat* the bystanders laughed immoderately" (*whereat* modifies *laughed;* we know it to be a Connective or Relative adverb because we could substitute "and thereat" for it). Again, "And now, too soon for us, the circling hours This dreaded time have compassed, *wherein* we Must bide the stroke of that long-threatened wound" (*Paradise Regained*).

Here we could substitute "and therein" for "wherein." The antecedent here is *time;* in the previous illustration the antecedent is "the fact of his falling." These Connective Adverbs must be distinguished from Conjunctions.

Negative Adverbs. *Not* is shortened from *nought* or *naught,* and literally means "in no whit, in no degree." In Old English, *ne* (= *not*) is employed before the verb, and a form corresponding to *naught* after the verb, the two negatives strengthening each other; thus, in Robert of Gloucester's *Chronicle* (A.D. 1298) we find "*Ne* be thou naught so sturne" ("Be thou not in any way so stern"), and in Chaucer's *Canterbury Tales* we have

"There was also a Doctour of Physik,
In all the world *ne* was there *none* him like.'

Also "Nor hath not one spirit to command" (*Tempest*).

In modern English, two negatives, so far from strengthening each other, neutralise each other.

although Matthew Arnold follows the old usage when he writes:

> "No easier nor no quicker pass'd
> The impracticable hours."

No and *nay* are from *na*, meaning *never*, while *aye* (affirmative) is from *a*, meaning *ever* (cf. *for aye*, meaning *for ever*. "This world is not for aye," *Hamlet*). *Yes* is from Anglo-Saxon *gese* or *gea*, yea, and *sy* (subjunctive mood, meaning "let it be").

Comparison of Adverbs. Most adverbs are compared by prefixing *more* and *most* to the positive, as *willingly, more willingly, most willingly*. But a few, and especially those which have the same form as the corresponding adjectives, are formed by the suffixes *-er*, *-est*; as:

Positive.	*Comparative.*	*Superlative.*
firm	firmer	firmest
fast	faster	fastest
soon	sooner	soonest
early	earlier	earliest

The following are irregular (see "Comparison of Adjectives" on page 446):

Positive.	*Comparative.*	*Superlative.*
well	better	best
badly, evilly, *or* ill	worse	worst
much	more	most
far	farther	farthest
forth	further	furthest
nigh *or* near	nearer	nearest next
late	later latter	latest last
[rathe, *adjective*]	rather	—
—	ere	erst
lief	liefer	—

Rathe meant *quick, early*; *Rather*, therefore, means *quicker, earlier, sooner*. Thus, in *Piers the Plowman*, by William Langland (A.D. 1362), we find it used as an adverb:

> "Let not thi luft hond, late ne *rathe*,
> Beo war what thi right hond worcheth or deleth."

("Let not thy left hand, late nor early, be aware of what thy right hand worketh or distributeth.")

Also Milton in *Lycidas* has "the *rathe* primrose" (adjective). Rath is still used in the Sussex dialect, as "Happens you were up *rath* this morning" (adverb), "She is given to taking long rambles in the *rath* morning" (adjective).

Ere is the Anglo-Saxon *aer*, a comparative adverb of time. It is now used mainly as a conjunction. *Erst* means *formerly*, and is shortened from *aerest*.

Position of Adverbs. Adverbs are usually placed as near as possible to the words they modify, and generally *before* an adjective or other adverb, and *after* a verb. For emphasis, however, an adverb may precede the verb, and even stand as the first word of a sentence. The poets take liberties with adverbs, and place them as they like; thus, Milton writes: "The rest . . . . will far be found unworthy to compare with Sion's songs," instead of "far unworthy." This usage should not be imitated.

Continued

FRENCH

Continued from page 1064

By Louis A. Barbé, B.A.

THE VERB

First Conjugation

The first conjugation consists of verbs of which the infinitive ends in *er*: *aimer*, to love, like; *donner*, to give; *garder*, to keep; *marcher*, to walk; *regarder*, to look: *représenter*, to represent.

The endings of all regular verbs of the first conjugation in the present indicative are: *e*, *es*, *e*, *ons*, *ez*, *ent*.

Affirmatively.

j'aime, I love
tu aimes, thou lovest
il aime, he loves
elle aime, she loves
nous aimons, we love
vous aimez, you love
ils aiment, they (m.) love
elles aiment, they (f.) love

Negatively.

je ne donne pas, I do not give
tu ne donnes pas, thou dost not give
il ne donne pas, he does not give
elle ne donne pas, she does not give
nous ne donnons pas, we do not give
vous ne donnez pas you do not give
ils ne donnent pas, they (m.) do not give
elles ne donnent pas, they (f.) do not give

The syllable *ent* of the third person plural is mute.

EXERCISE VI.

Vocabulary.

un appétit, an appetite
un arbre, a tree
une aubépine, a hawthorn
un aubour, a laburnum
en automne, in autumn
la baie, the berry
le bâtiment, the building
le bord, the edge
le bout, the end
la brebis, the sheep
la campagne, the country
la cerise, the cherry
le cerisier, the cherry tree
la charrette the cart
le chaume, the thatch
le cheval, the horse
le clocher, the steeple.
la colline, the hill
le contrevent, the shutter
la cour, the courtyard
la couverture, the cover
le cuisinier the cook
une eau, a water
une écurie, a stable (for cattle)
une église, a church
en été, in summer
une étable, a stable (for horses)

un exercice	**an exercise**
la faim	the hunger
la ferme	the farm
le festin	the feast
la feuille	the leaf
la fille	the girl
le fruit	the fruit
le facteur	the postman
la girouette	the vane
la gravure	the engraving
l'herbe (f.)	the grass
en hiver	in winter
un homme	a man
le houx	the holly
le jardin	the garden
la jument	the mare
la laine	the wool
le lait	the milk
le laurier	the laurel-tree
la lettre	the letter
le lilas	the lilac
le magasin	the shop
le mets	the dish (food)
la neige	the snow
le pré	the meadow
la personne	the person
la poire	the pear
le poirier	the pear-tree
la pomme	the apple
le pommier	the apple-tree
le pont	the bridge
au printemps	in spring
le repas	the meal
la rue	the street
le réverbère	the street-lamp
la rivière	the river
le sac	the bag
le sorbier	the mountain-ash
la terre	the ground
le trottoir	the footpath
la vache	the cow
le verger	the orchard
la ville	the town
une yeuse	an evergreen oak
la voiture	the carriage
agréable	pleasant
beau	fine, beautiful
blanc	white
bon	good
clair	clear
doux	sweet
frais	fresh
fin	delicate, dainty
grand	big, tall
gai	cheery
haut	high
joli	pretty
large	broad
luisant	glossy
mûr	ripe
nouveau	new
nu	bare
piquant	prickly
plein	full
propre	clean
rouge	red
savoureux	luscious
triste	dreary, sad
utile	useful
vert	green
vieux	old
garder	to keep
je prends	I take
je vais	I go
je vois	I see
à	at, to
au delà de	beyond
de	of, from
derrière	behind
devant	before, in front of
par	through, by
parmi	amongst
aussi	also
plusieurs	several
toujours	always
quand	when

I look through the window. In front of the window there is a large garden. In the garden there are some trees. Amongst the trees there are a fine laburnum, a pretty lilac, a hawthorn, an evergreen oak, and a mountain-ash. There are also some laurel-trees. They are always green. The evergreen-oak also is always green. In autumn the mountain-ash has berries. They are red. In winter the holly has berries also. The leaves of the holly are glossy and prickly. In spring the holly and the mountain-ash have no berries. Beyond the trees I see a bridge. Under the bridge there is a small river. The water of the river is fresh and clear. Beyond the bridge there is a broad street. The street has two footpaths. At the edge of the footpaths there are some street-lamps. In the street there are several persons. They walk on the footpath. One of the persons is a postman. He has a bag full of letters. There are also a carriage and a horse. There is no cart. At the end of the street there is a church. It has a fine steeple. The steeple is high. It has a vane. The church is not old, it is new. From the window I go to the table. I take a little book. The cover of the book is blue. In the book there are some pretty engravings. One of the engravings represents a farm. The farm is in a large courtyard. It has a stable-for-horses and a stable-for-cattle. In the stable-for-cattle there are cows. The cow gives milk. The stable is the horses' house. The stable is not a large building. In the stable there are a young horse and an old mare. Near the farm there is a meadow. In the meadow there are sheep. A little girl keeps the sheep. The sheep gives wool. The wool of the sheep is useful to (the) man. Behind the farm there is an orchard. In the orchard there are apple-trees, pear-trees, and cherry-trees. (The) apples are the fruit of the apple-tree. (The) apples are good when they are ripe. (The) cherries are the fruit of the cherry-tree. They are sweet. (The) pears are luscious. I like the country. In summer I go to the country. I have a little house on a pleasant hill. It is white. The shutters are green. The roof is of thatch. It is clean and cheery. In (at) the country (the) exercise gives a new appetite. (The) hunger is a good cook (f.). The dishes are dainty. The meals are feasts. In winter I do not like the country. It is bare and dreary. The trees have no leaves. There is snow on the ground. In winter I like the town.

FORMATION OF THE PLURAL

Nouns and Adjectives

Nouns and adjectives form their plural in the same way, and according to the following rules:

1. To form the plural of nouns and adjectives, add *s* to the singular: *le livre*, the book, *les livres*, the books; *un enfant poli*, a polite child, *des enfants polis*, polite children; *la belle orange*, the fine orange, *les belles oranges*, the fine oranges.

2. When the singular ends in *s*, *x*, *z*, there is no change for the plural: *le fils*, the son, *les fils*; *la voix*, the voice, *les voix*; *le nez*, the nose, *les nez*; *un fils doux et soumis*, a gentle and dutiful son, *des fils doux et soumis*.

3. When the singular ends in *au*, *eau*, *eu*, the plural is formed by adding *x*: *le noyau*, stone (of fruit), *les noyaux*; *le bateau*, boat, *les bateaux*; *le feu*, fire, *les feux*; *un livre hébreu*, a Hebrew book, *des livres hébreux*. The noun *landau*, landau, and the adjectives *bleu*, blue, and *feu*, late (deceased), take *s* for the plural: *un landau bleu*, a blue landau, *des landaus bleus*; *le feu prince*, the late prince, *les feus princes*.

4. The following seven nouns in *ou* also take *x* for the plural: *bijou*, jewel; *caillou*, pebble; *chou*, cabbage; *genou*, knee; *hibou*, owl; *joujou*, toy; *pou*, louse. All other nouns in *ou*, and all adjectives in *ou* take *s*: *le clou*, nail, *les clous*; *le verrou*, bolt, *les verrous*; *un corps mou*, a soft body, *des corps mous*; *un prix fou*, an extravagant price, *des prix fous*.

5. When the singular ends in *al*, the plural is formed by changing *al* into *aux*: *le mal*, evil, ache, *les maux*; *le cheval*, horse, *les chevaux*;

le tribunal, *les tribunaux*; *un conseil amical*, friendly advice, *des conseils amicaux*; *l'instinct brutal*, brutal instinct, *les instincts brutaux*. Exceptions: The following (*a*) nouns and (*b*) adjectives take *s* for the plural: (*a*) *aval*, endorsement; *bal*, ball (party); *cal*, callosity; *carnaval*, carnival; *chacal*, jackal; *nopal*, nopal (Indian fig); *pal*, pale; *régal*, treat; (*b*) *fatal*, *final*, *filial*, *glacial*, *jovial*, *magistral* (masterly), *matinal* (matutinal), *mental*, *natal*, *naval*, *pénal*, *sentimental*.

6. The nouns in *ail* in common use are nearly equally divided between (*a*) those that form their plural by changing *ail* into *aux*, and (*b*) those that only add *s*.

(*a*) *Bail*, lease, *baux*; *corail*, coral, *coraux*; *émail*, enamel, *émaux*; *soupirail*, air-hole, *soupiraux*; *vantail*, leaf of folding-door, *vantaux*; *vitrail*, stained-glass window, *vitraux*.

(*b*) *Camail*, bishop's cape, *camails*; *détail*, detail, *détails*; *éventail*, fan, *éventails*; *gouvernail*, rudder, *gouvernails*; *poitrail*, chest (of horses), *poitrails*; *portail*, porch, *portails*.

7. The plural of some nouns offers peculiarities and irregularities: (*a*) *aïeul* in the singular means grandfather, and has *aïeuls* for its plural: *il a deux aïeuls*, he has two grandfathers. It has a second plural form with the meaning of ancestors: *il a des aïeux nobles*, he has noble ancestors. In this second sense the word is never used in the singular. It is customary to say "one of the ancestors," instead of "an ancestor."

(*b*) *Ail*, garlic, has two plurals, *ails* and *aulx*. Botanists prefer the regular form: *la famille des ails*, the garlic family. The irregular form is more commonly used: *il y a des aulx cultivés et des aulx sauvages*, there are cultivated garlic plants and wild garlic plants.

(*c*) *Ciel*, sky, heavens, usually has the plural *cieux*: *la voûte des cieux*, the heavenly vault. When *ciel* is used (*a*) to indicate the skies of pictures, (*b*) as the equivalent of climate, or (*c*) in a figurative sense, its plural is *ciels*: (*a*) *il peint de beaux ciels*, he paints beautiful skies; (*b*) *la Grèce et l'Italie sont situées sous de beaux ciels*, Greece and Italy are situated beneath beautiful skies; (*c*) *des ciels de lit*, bed testers.

(*d*) *Œil*, eye, usually has the plural *yeux*: *elle a de beaux yeux*, she has beautiful eyes. In compound words in which it is used figuratively, it forms its plural regularly: *des œils-de-bœuf*, bullseye windows; *des œils-de-chat*, catseyes (precious stones).

(*e*) *Travail*, when it means work, has the plural *travaux*: *des travaux manuels*, manual labour. When used in the sense (*a*) of a brake for shoeing vicious horses, or (*b*) of official reports to the head of a department, it forms its plural regularly.

(*f*) *Bétail* has no plural, and *bestiaux* has no singular. Both mean cattle, and may be used to supplement each other.

8. Some nouns have one meaning in the singular and two meanings in the plural. The most usual of these are: *une arme*, weapon, *des armes*, weapons, and coat of arms; *un arrêt*, stoppage, *des arrêts*, stoppages, and arrests; *le ciseau*, chisel, *les ciseaux*, chisels and scissors; *la défense*, defence, *les défenses*, defences, and tusks; *le fer*, iron, *les fers*, different kinds of iron, and fetters; *la lunette*, telescope, *les lunettes*, telescopes, and spectacles.

9. Some nouns are used only in the plural. The most common of them are:

les agrès (m.), rigging
les alentours (m.), surroundings
les broussailles (f.), brushwood
les décombres (m.), rubbish
les dépens (m.), costs
environs (m.), environs
fiançailles (f.), betrothal
frais (m.), expenses
funérailles (f.), funeral
immondices (f.), filth
matériaux (m.), material
mœurs (f.), morals, manners
obsèques (f.), obsequies
ténèbres (f.), darkness
vivres (m.), provisions

EXERCISE VII.

1. There are some beautiful books.
2. The children are polite.
3. You have some fine oranges.
4. Boats have rudders.
5. Peaches (*pêche*) and apricots have stones.
6. We have given prizes (*prix*) to the pupils (*élève*).
7. The doors have no bolts.
8. The children's toys are broken (*cassé*).
9. The princess's jewels have cost (*coûté*) exorbitant prices.
10. There are some cabbages in the garden.
11. The shepherds (*berger*) tend (*gardent*) the flocks (*troupeau*).
12. Horses are useful animals.
13. There are no jackals in England (*Angleterre*).
14. The churches (*église*) have beautiful stained-glass windows.
15. The generals have noble ancestors.
16. We have no need of fans.
17. The little girls have blue eyes (the eyes blue).
18. They have given several (*plusieurs*) balls.
19. The vault of the heavens is strewn with (*parsemée de*) stars (*étoile*).
20. The works of men are perishable (*périssable*).

KEY TO EXERCISE V. (page 907)

1. Il y a quatre saisons: le printemps, l'été l'automne, et l'hiver. 2. Le printemps est la première saison de l'année. 3. L'hiver n'est pas la saison des fleurs. 4. En été il n'y a pas de neige. 5. Le mois de Décembre est un des mois de l'hiver. 6. La pomme est le fruit du pommier. 7. Le rosier n'a pas des fruits. 8. Le chêne est un arbre, la bruyère est un arbrisseau. 9. Il y a un hêtre et une aubépine derrière la maison. 10. Il a une prune, elle a un abricot, et nous avons des cerises. 11. Il y a un oiseau dans la cage. 12. Les enfants sont sur la plage. 13. Le frère et la sœur ont la rougeole. 14. J'ai une migraine. 15. Le mensonge est un vice. 16. La sentinelle n'est pas une recrue. 17. Il y a une gravure sur la première page du livre. 18. J'écris avec la craie. 19. Le marin et le mousse aiment la mer. 20. La fin de la leçon.

Continued

GERMAN

Continued from page 1056

By P. G. Konody and Dr. Osten

Gender of Nouns, Adjectives, etc.

XII. Of FEMININE GENDER are:

(*a*) Substantives denoting female persons [see VII. 1].

(*b*) Many animals of both sexes.

(*c*) Nouns ending in -ei, -eit, ſchaft, ung, and -ucht.

(*d*) The names of most trees, except compounds with -Baum (*m.*) tree, which are always masculine [see XII. 2].

(*e*) Inanimate objects ending in e.

(*f*) Such words ending in in, as are formed from the correlative masculine by the addition of this suffix which denotes the female gender. (Masculine nouns ending in -e in this case drop this letter, and in some cases the stem vowel is modified.) Der König, the king; die König-in, the queen; der Graf, the count; die Gräf-in, the countess; der Löwe, the lion; die Löw-in, the lioness; der Hund, the dog; die Hünd-in, the bitch; der Franzo'ſe, the Frenchman, die Franzoſ'-in*, the Frenchwoman; der Bauer, the peasant, die Bäu'er-in, the peasant-woman.

(*g*) The wives of persons with academical and certain professional titles are generally addressed with feminised modifications of these titles. The wife of a doctor, professor, parson, councillor, major, etc., is addressed as Frau Doctor-in, Profeſſor-in, Pfar'rer-in (der Pfarrer, the parson), Räth-in (der Rath, the councillor), Major'-in.

(*h*) The names of a few countries, which are always used with the definite article

EXAMPLES: (*a*) die Tochter, the daughter; die Schweſter, the sister.

(*b*) die Lerche, the lark; die Hyäne, the hyena.

(*c*) die Schmeichelei', flattery; die Frei'heit, liberty; die Freu'ndſchaft, friendship; die Eri'nnerung, remembrance; die Schlucht, the gorge, ravine.

(*d*) die Eiche, the oak (but der Eichbaum, the oak tree); die Pappel, the poplar; die Lärche, the larch; die Fichte, the pine.

(*e*) die Tinte, the ink; die Roſe, the rose; die Güte, the kindness, etc. EXCEPTIONS: der Käſe, the cheese; das Auge, the eye.

(*h*) die Türkei', Turkey; die Schweiz, Switzerland; die Krim, the Crimea; die Mol'dau, Moldavia; die Wallachei', Wallachia, etc.

Of NEUTER GENDER are:

1. (*a*) All words which are not substantives, but are used substantively, and are therefore written with capitals.

(*b*) The names of some countries and towns, which take the article das when preceded by adjectives.

(*c*) All diminutives ending in -chen and -lein. [See VII.].

(*d*) Most nouns ending in -nis, ſal, and tum.

(*e*) Many metals.

(*f*) The majority of collective nouns with the prefix Ge-.

EXAMPLES: (*a*) das Tanzen (infinitive of a verb with a capital), the (act of) dancing; das Erha'bene, the sublime (adjective used substantively); das Viel'fache, the manifold (indefinite numeral), etc.

(*b*) das ſo'nnige Ita'lien, sunny Italy; das ne'belige England, foggy England; das unerme'ßliche London, immense London; das reiche Hamburg, rich Hamburg.

(*c*) das Brü'derchen (diminutive of der Bruder), das Mütterlein (dimin. of die Mutter), das Blü'melein or das Blümchen (dimin. of die Blume, the flower).

(*d*) das Hin'dernis, the obstacle; das Schick'ſal, the fate; das Hei'ligtum, the sanctuary. EXCEPTIONS: die Ke'nntnis, (*f.*) the knowledge; die Drangſal (*f.*), the affliction, trouble; der Reichtum (*m.*) wealth; and a few others.

(*e*) das Eiſen, iron; das Blei, lead; das Kupfer, copper; das Silber, silver. EXCEPTION: der Stahl, steel.

(*f*) das Gebir'ge, the mountain range; das Gefo'lge, the retinue; das Gewölk', the clouds, etc. But there are also many EXCEPTIONS; for instance: die Gemein'de (*f.*), the community; der Geſang' (*m.*), the singing, song.

2. COMPOUND NOUNS take their gender from their last component—*e. g.*, der Poſt'bote (*m.*) the postman, [die Poſt (*f.*) and der Bote (*m.*) messenger]; die Brief'taube (*f.*) the carrier-pigeon, [der Brief (*m.*) letter, and die Taube (*f.*) pigeon, dove]; das Gar'tenfeſt (*n.*) the garden party, [der Garten (*m.*) and das Feſt (*n.*) the festivity]. In some compound words an e or s is inserted for the sake of euphony.

3. COMPOUNDS OF ADJECTIVES OR PREPOSITIONS WITH SUBSTANTIVES generally take the gender of the substantive, but there are exceptions to this rule; for instance: die An'mut (*f.*) the grace, [der Mut (*m.*) courage]; die Sanftmut (*f.*) gentleness, tenderness [ſanft, gentle, and der Mut]; der Ab'ſcheu (*m.*) the aversion, [die Scheu (*f.*) bashfulness].

4. A few substantives have two genders which can be used indiscriminately; for instance; der (*m.*) or das (*n.*) Me'ter (the metre), Liter (litre), Thermome'ter, Barome'ter, Scepter (sceptre); die (*f.*) or das (*n.*) Verderb'nis, corruption, depravity; der or die Hausflur, lobby, entrance hall; der or das Un'geſtüm, impetuosity, etc.

5. The following substantives change their meaning with the gender:

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* EXCEPTION: Der Deutſche, the German, die Deutſche (*not* die Deutſchin), the German woman.

r Band (*m.*) volume [of a book]	das Band (*n.*) ribbon
, Bauer (*m.*) peasant	,, Bauer (*n.*) [bird-] cage
, Bund (*m.*) league	,, Bund (*n.*) bundle
, Chor (*m.*) choral-song, or chorus	,, Chor (*n.*) locality in the church for the choir
, Erbe (*m.*) heir	,, Erbe (*n.*) inheritance
e Erkenntnis (*f*) insight	,, Erkenntnis (*n.*) judicial verdict
r Gehalt (*m.*) contents	,, Gehalt (*n.*) salary
Geißel (*m.*) hostage	die Geißel (*f.*) scourge
, Haft (*m.*) clasp	,, Haft (*f.*) prison, custody
Harz (*m.*) Harz Mountains	das Harz (*n.*) resin, gum of trees
Heide (*m.*) heathen	die Heide (*f.*) heath
, Hut (*m.*) hat	,, Hut (*f.*) heed, guard
, Kiefer (*m.*) jaw	,, Kiefer (*f.*) fir
, Kunde (*m.*) customer	,, Kunde (*f.*) news intelligence
, Leiter (*m.*) manager, guide	,, Leiter (*f.*) ladder
e Mark (*f.*) province, boundary, Germ. coin	das Mark (*n.*) marrow
r Menſch (*m.*) man	,, Menſch (*n.*) wench, hussy
Meſſer (*m.*) measurer	,, Meſſer (*n.*) knife
Reis (*m.*) rice	,, Reis (*n.*) sprig, twig
, Schild (*m.*) shield	,, Schild (*n.*) sign—board
, See (*m.*) lake	die See (*f.*) sea
Sproſſe (*m.*) offspring	,, Sproſſe (*f.*) step of a ladder
e Steuer, (*f.*) rate, tax	das Steuer (*n.*) helm, rudder
r Stift (*m.*) pencil	,, Stift (*n.*) monastery, chapter
, Teil (*m.*) part	,, Teil (*n.*) due, share
Thor (*m*) fool	,, Thor (*n.*) gate
Verdienſt (*m.*) gain, profit, earnings	,, Verdienſt (*n.*) merit
- Wehr (*f.*) defence	,, Wehr (*n.*) weir, dyke, ditch

Inflections of Weak Verbs

XIII. In the IMPERFECT a *weak verb* se X.] takes the following inflections:

INDICATIVE.

Singular

1.	-ete or -te	ich lob-te	I praised
2.	-eteſt or -teſt	du lob-teſt	thou praisedst
3.	-ete or -te	er lob-te	he praised

Plural

1.	-eten or -ten	wir lob-ten	we praised
2.	-etet or -tet	ihr lob-tet	you ,,
3.	-eten or -ten	ſie lob-ten	they ,,

1. The inflections of the conjunctive are identical with those of the indicative.
2. The first -e of the inflections -ete, -eteſt, etc. is generally dropped, but retained for euphony's sake in verbs with stems ending in -d, -n, -ſt, -t; like: bad-en, to bathe; athm-en, to breathe; koſt-en, to cost or to taste; wart-en, to wait; (1. *sing.* ich bad-ete; 2. du athmet-eſt; 3. er koſt-ete; 1. *plur.* wir wart-eten, etc.). For the same reason the first e of the inflections is sometimes dropped, sometimes retained, in verbs with stems ending in -n. Thus it is dropped in ahn-en, to forebode; gähn-en, to yawn; lern-en, to learn, etc., and retained in öffn-en, to open; rechn-en, to reckon; zeichn-en, to draw or design. (1. *sing.* ich ahn-te; 2. du gähn-teſt; 3. er lern-te; but 1. *plur.* wir öffn-eten; 2. ihr rechn-etet; 3. ſie zeichn-eten).

The IMPERFECT is the distinguishing trait of the weak and strong conjugations [see X_1]. Weak verbs form this tense by taking suffixes, strong verbs by changing the stem vowel. Reden (stem: red-) and ſprechen (stem: ſprech-)—either of which signifies, to speak—form the imperfect: ich red-ete (weak) I spoke, and ich ſprach (strong) I spoke, the latter merely changing the stem vowel e into a.

EXAMINATION PAPER IV.

1. What is the usual gender of trees, and under which conditions is it changed?
2. How are feminine nouns formed from masculine nouns which have no separate feminine correlative?
3. What is the gender of nouns terminating in e, and indicating inanimate objects? Are there any exceptions?
4. What is the gender of nouns which are not substantives, but are used substantively?
5. Which nationality is exempt from the rule referred to in question 2?
6. Which gender is taken by compound substantives?
7. Which letters are sometimes inserted between the components of a compound noun, and why?
8. By which tense is it easiest to recognise whether a verb belongs to the weak or to the strong conjugation?

2. In which cases is the first e of the inflections of the weak imperfect retained?

10. Which is the most characteristic feature of the strong imperfect?

11. Are there any differences in the inflections of the weak imperfect in the indicative and in the conjunctive?

12. For what reasons is the first e in the inflections of the weak imperfect frequently dropped?

EXERCISE 1.* Insert the missing articles, verbs and nouns.

. . . . Tante redet mit . . . . Nichte; . . . . Schweſter
The aunt speaks to the niece; the sister
. . . . . Mädchens iſt ſchön; ich liebe . . . . Eiche,
of the girl is pretty; I love the oak,
. . . Pappel, und . . . Kaſtanien-Baum; . . . Höflichkeit
the poplar, and the chestnut(-tree); the civility

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* To avoid confusion, the German phraseology has been adopted for the English translation of German sentences, so that each English word is placed under its German equivalent.

. . . . . . Engländers iſt bekannt; . . . Erinnerung iſt
of the Englishman is known; remembrance is
. . . Prüfſtein (see VII. b and XII. 2) . . . Vergangenheit;
the touchstone of the past;
. . . . Wieſe war grün und . . . . Heide braun:
the meadow was green and the heath brown:
. . . . . Käſe iſt friſch.
the cheese is fresh.

. . . . Fürſt ſchreibt; . . . . lobte . . . .
the prince writes; the princess praised the
Kinder; . . . Baron und . . . . kommen heute;
children; the baron and the baroness come to-day;
. . . Wolf und . . . . Fuchs und . . .
the wolf and the she-wolf, the fox and the
. . . . . ſind Raubthiere; . . . . Blüm'chen
she-fox are beasts of prey; the little flower (dimin.)
blüht; . . . . Vöglein ſingt;
blossoms; the little bird (dimin.) sings;
Finſternis war undurchdringlich; . . . Heldentum
the darkness was impenetrable; the heroism
. . . Griechen; . . . Gold und . . . Silber . . . Metalle;
of the Greeks; gold and silver are metals;
. . . alte . . . Zinn iſt heutzutage werthvoll; . . . Stahl . . . .
old tin is nowadays valuable; the steel of the
Degens . . . . biegſam; . . . . Geſchick . . . . Mannes
sword was pliable; the fate of the man
erweckte . . . Gefühl . . . Mitleids; . . . Geſang
awakens the sentiment of pity; the singing
. . . . Gemeinde und . . . . Gebet . . . . Pfarrers
of the community and the prayer of the parson
waren hörbar.
were audible.

Exercise 2. Form compound nouns with their articles from the substantives:

Der Wald, the wood (forest); die Quelle, the source: Waldquelle. Der Bach, the brook; die Forelle, the trout: Bachforelle. Die Forelle, der Bach: Forellenbach. Der Vogel, the bird; das Neſt, the nest: Vogelneſt. Das Neſt, der Vogel: Neſtvogel. Der Berg, the mountain; die Kette, the ridge (or chain): Bergkette, the ridge or chain of mountains. Die Hand, the hand; der Schuh, the shoe: Handſchuh, the glove.

Exercise 3. Insert the different articles of the consonant substantives with different meaning:

. . . . See iſt oft ſo wild wie . . . . See; . .
the lake is often as rough as the sea; the
Kunde erreichte . . . Kunden; . . . Verdienſt
intelligence reached the customer; merit
und . . Verdienſt begegnen einander nicht immer;
and gain meet (each other) not always;
(do not always meet)
. . . . Erkenntniß zeigt . . . Erkenntniß des Richters;
the judicial verdict shows the insight of the judge;
. . . Thoren kommen durch . . . . Thor des Gartens
the fools come through the gate of the garden.

Exercise 4. Add to the stem the conjugational inflections:

Ich reiſ . . . mit ihm; wir wander . . .* durch den
I travelled with him; we walked through the
Garten; ſie zeichn . . fleißig; Sie zeichn . . ein Bild;
garden; you drew diligently; you drew a picture;
ſie liebt . . einander zärtlich; ſie liebt . . den
they loved each other tenderly; she loved the
Vater; wir atm . . . . . kaum; er rechn . . . laut;
father; we breathed scarcely; he reckoned aloud;
du arbeit . . . und blick . . .* nicht nach mir; ſie wart . .
you worked and glanced not at me; she waited
und wander . . dann fort; du erzähl . . .* die
and walked then away: you narrated the
Einzelheiten, die Mutter ſtrick . .*, wir arbeit . . . .,
particulars, the mother knitted, we worked,
ſie rechn . . . . ., die Kinder ſpiel . . .*, nur der
you calculated, the children played, only the
Vater fehl . . . ; er . . . . nicht daheim.
father was missing; he was not at home.

* wander:n, to walk, wander; blick:en, to look, glance; erzähl:en, to narrate; ſtrick:en, to knit; ſpiel:en, to play.

Continued

Group 25

PHYSIOLOGY

8

Continued from page 967.

THE STREAM OF LIFE

How the Blood Circulates. Action of the Heart, Arteries, Capillaries and Veins. Pulsation. Vascular Glands. Lymphatic System

By Dr. A. T. SCHOFIELD

WE have considered the whole system of vessels, large and small, that convey the blood to every part of the body, and examined the wonderful pump by means of which the life stream is propelled once round the body every minute. All this can, of course, be looked at after death ; and if any student is interested enough to verify the facts we have described, and shall describe, in this course, an admirable way of doing so is to buy a skinned rabbit that has not had its internal organs removed, and then, with a common pen-knife and a pair of forceps, the leading facts of anatomy can, with little trouble, be clearly made out ; and although the arrangement in a rabbit is not exactly that of a human being, it is quite near enough for all practical purposes.

The Blood in Circulation. But now we have to follow mentally what cannot be seen by dissection—and that is, the blood in actual circulation.

The best way is to begin with the heart and follow the course of the blood through the various chambers there, bearing in mind at the outset one or two leading facts. The blood enters the heart on the right side, and finally leaves it for the body on the left. The right heart is always full of bluish, or venous, blood ; the left of bright red, or arterial, blood.

The actual movement through the heart, then, is as follows: The two upper chambers communicate with the lower by means of folding doors or valves, but there is no opening between the right and the left sides of the heart.

The Heart an Automatic Pump. The blood arrives at the right side of the heart by the two large veins from the upper and lower parts of the body. Just before the inferior vena cava, or lower vein, reaches the heart, it receives its fresh supply of food by a large vessel from the liver that opens into it ; and just before the superior vena cava, or upper vein, reaches the heart, it receives all the chyle, or digested fat, together with the purified lymph, from the body, so that the venous blood which pours into the heart is not the same as that which left the capillaries, but has already received its fresh supplies of nourishment. All it now wants is the oxygen from the fresh air to restore its bright colour. The blood enters the heart by the *right auricle*, and pours down through the open valve in the floor into the *right ventricle* below. As this fills with blood, the flaps of the valve—three in number (hence it is called the tricuspid valve, because it has three cusps, or flaps)—float up on the blood and close together gradually. When the right ventricle is quite full, the heart contracts forcibly, and all the blood is forced out of the ventricle, through another valve with three flaps, along a short artery called the pulmonary, or lung artery, because it takes the blood to the lungs to be charged with fresh air. It then passes through the innumerable lung capillaries.

When the blood has received its supply of oxygen, it returns by *four vessels*, called the pulmonary veins, to the *left auricle*. It pours through the valve in the floor (which is called the mitral valve, because it is like a bishop's mitre, and has only two flaps, or cusps) into the *left ventricle*. As this fills, the cusps of the mitral valve are floated up and closed. The heart then contracts vigorously (at the same time as on the right side) by sudden muscular action of the walls (which are over half an inch thick) and forces all the blood through another valve with three flaps, called the aortic valve, into the aorta. This squeezing of the heart can only drive the blood in one direction, on account of the valves. If you get an indiarubber syringe, which has a ball to squeeze in the middle, and a tube at each end [55], and put the shorter end into water and squeeze, as the ball expands again it sucks the water in to fill the ball ; and then, as you squeeze it again, a valve prevents the water being forced back, and it rushes along the other pipe and comes out in a jet. The short pipe in the water may represent the veins, the ball the heart, and the other pipe, out of which the water flows, the arteries.

Pulsation. The contraction of the heart we call the beat, and it occurs about seventy times a minute, and gives the throb, or pulsation, to the blood in the arteries ; this flows in jerks (as you see when one is cut), while the blood in veins flows in a slow and steady stream.

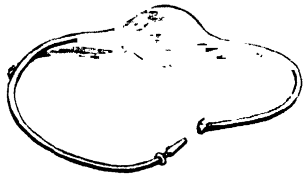
The Greater and Lesser Circulations. We thus see there are two principal circulations—one called the systemic, or *greater, circulation*, that circulates through the system or body ; and the other the pulmonary, or *lesser, circulation*, that circulates through the lungs. In the former the blood *loses* oxygen, gains *carbonic acid*, and becomes dark and impure ; in the latter the blood *loses carbonic acid*, gains *oxygen*, and becomes bright and pure.

The strength of the beat of the left ventricle is double that of the right, and the whole force exerted by the heart is equal to 120 tons lifted one foot high, or the heart's own weight raised 20,000 ft. every hour. The greatest height an active man can raise himself is 1,000 ft. an hour ; a locomotive can raise itself nearly 3,000 ft., while the heart raises itself higher than Mont Blanc.

How the Heart Rests. There is an idea that the heart is more incessantly at work than other organs. Such is not the case, but the periods of rest alternate much more rapidly. All working parts of the body have their intervals of rest—the brain when we sleep; the stomach, eyelids, diaphragm, etc., at shorter intervals.

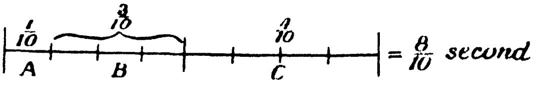
If the whole circle of the heart's action be completed in $\frac{8}{10}$ of a second, half of this is rest, as is represented in 56. The contraction of the heart is called the *systole*, the rest the *diastole*.

The movements of the heart are mainly caused by three sets of ganglia in the heart itself. With proper care, a heart can therefore beat when out of the body altogether, and even when cut in three pieces, each of which includes one of these ganglia, or nerve centres.



55. SYRINGE ILLUSTRATING ACTION OF THE HEART AND VALVES

Arterial Circulation. Passing on now to the course of the blood in the arteries, we must remember that we have not here to deal with a series of rigid pipes, but highly elastic tubes. This elasticity is a very important property in more ways than one. In the first place, the beat of the heart on the injection of four tablespoonfuls of blood into the aorta is intermittent, and takes place about seventy times a minute, or at least every second. Now, such is the force of the automatic pump we call the heart that, as we have said, it lifts its own weight higher than Mont Blanc every hour. This force, if an artery were a rigid tube like a gas-pipe, would draw the blood along in jerks at about 200 ft. a second. As it is, the force first of all distends the elastic artery so that you can feel it swelling beneath the finger at the wrists, and can also often notice it with the eye there, and at the temples. Then, in the intervals between the beats, the contraction of the overstretched artery still keeps up the pressure on the blood, and forces it along the vessel, converting by this means an intermittent propelling power of 200 ft. a second into a steady flow of about 1 ft. a second, which is the average arterial speed of the blood until the capillaries are reached. We have already stated that if the arterial calibre be represented by a tube 1 in. in diameter, that of the united capillaries would be about 2 ft., or nearly 600 times as great.



56 ONE BEAT OF THE HEART

A. Auricular Systole = $\frac{1}{10}$ sec. *B*. Ventricular Systole = $\frac{3}{10}$ sec. *C*. Diastole, or pause = $\frac{4}{10}$ sec.

The Rush of the Blood Checked. Here, then, the rush of the blood is completely checked. It is like a river flowing into a lake, and not only into a lake, but into a network of tiny channels equal in size to a lake, and involving loss of power by friction against their million walls. All this reduces the blood speed from 1 ft. a second to 1 in. a minute. On this retardation, as we have shown, our life depends. It is useless whisking food at 60 miles an hour past our doors. It is all very well to bring it up at this speed from all parts of the country; but when it has to be distributed in towns we no longer use trains at 60 miles an hour, but butchers' and bakers' carts that stop and deliver at every door; we should die of starvation otherwise. A parallel case occurs here. The air and food cannot be brought too quickly to the populous cell towns; but once there it is carried slowly from door to door that each may take his share, and all be satisfied. So far, from all we have said, it might be supposed that the process is simply mechanical. A well-made pump beating ever at 70 strokes a minute forces the blood into miles of tiny tubes, through which it circulates at a fixed rate. But such is not the case. In the first place the circulation in the arterial system depends, of course, upon the heart's beat; but this is by no means uniform nor equally forcible, for in its turn it is controlled from the lower brain by an intelligent force often termed "Nature," but which I call the unconscious mind. The control may be partly reflex—that is, the result of stimuli; but those who have thought more on the subject are convinced that even in reflex action there is something more than mere mechanism, that some power beyond matter is at work—there is the directing agent of mind.

Action of the Capillaries. Once, however, the capillaries are reached the power that controls the movement of the blood is no longer the heart force with which it is propelled, but the opening or closing of the channels through which it has to flow. There is, as we shall see when we study the nervous system, and as we have briefly pointed out in speaking of assimilation, a central power that controls absolutely the opening and closing of the miles of capillaries in the body, so that they are incessantly varying according to the changing needs of the economy, and its requirements not only of food but of heat. For we must ever remember that this great circulation of hot food through the body not only feeds it but warms it.

We cannot here go into the wonderful way in which whole tracts of capillaries are thus incessantly being opened and closed according to the body's needs. Suffice it to say the process is so remarkable, and so beyond mere mechanism, that were there no other indication of a central intelligent controlling force, this would suffice.

We need not linger longer on the passage of the blood through these tiny channels, for the section on assimilation has covered the same ground

The Blood in the Veins. When we come to the veins we find for the first time the circulation begins to be in difficulties. It is easy to drive the blood from the heart to the capillaries, say, of the great toe: the difficulty is to get it back again. It is in every sense uphill work, for the force of the heart is well-nigh spent as far as direct impulse goes, owing to the passage through the capillaries; but still a certain compulsion from behind remains to help the blood, now venous in colour and quality, back to the heart.

Exercise Aids Circulation. The second help that comes into play arises from the fact that the walls of the veins are thinner than the arteries, and as they are placed between the large muscles in many cases, muscular contraction in the exercise of arms and legs squeezes these veins so forcibly as almost to act as another pump. Of course a moment's reflection will show that squeezing a pipe alone does not propel the contents—it simply forces some portion back and some a little forward. Valves are required that open towards the heart, but cannot be opened backwards, and these, as we have seen, the veins possess; so that every squeeze can only move the blood in one direction, and that is towards the heart. Here we see the great value of exercise in aiding the venous circulation. Without it the venous blood tends to stagnate, and all the vital processes are retarded as the circulation becomes enfeebled.

The Part Played by Respiration. The next help the circulation gets is from the respiration, in which the pressure on the large blood-vessels and heart is withdrawn, and then the blood is sucked up towards that organ. The factors, then, that bring the blood back from the capillaries to the heart are: (1) The heart's beat; (2) the thinness of the veins; (3) the squeezing by muscle contraction; (4) the valves; (5) respiration. And thus in almost one minute the blood flows from the left to the right side of the heart.

When the Blood Leaves the Heart. Blood, when it leaves the heart, has its choice of one of five courses. This is briefly described in the diagram [57].

The *shortest* is round the walls of the heart itself to nourish its muscles, starting from the left side and returning through the right veins. This is called the *coronary* circulation.

The *next* longer is from the pulmonary artery in the right side of the heart through the lungs and back to the left side of the heart by the four pulmonary veins. This is called the *pulmonary* circulation.

The second longer is from the left side of the heart through the walls of the digestive organs and kidneys, receiving the food and carrying it into the liver and also getting rid of any refuse, and flowing back to the right side of the heart. This is called the *digestive* circulation.

The *third* longer is from the left side of the heart through the brain by special capillaries and veins that cannot close, which we shall describe later, and so back to the right side of the heart. This is called the *cerebral* circulation.

The *last* and longest is through every part of the body, and this is the *systemic* circulation, and has been already described.

What is the Pulse? The pulse is not the actual flow of the blood, which would certainly appear to be intermittent, as indeed it is, when it spurts out of a cut artery. In the closed artery, however, it is not, as we have shown, intermittent, but is steady, owing to the pressure of the blood in front and the give of the elastic arterial walls. The pulse is the wave sent along the blood by the beat of the heart, by the forcing into the aorta of the fresh supply of blood. This wave passes down the blood-stream, stretching the wall of the artery as it travels along twenty-eight times as fast as the blood itself flows. The pulse, therefore, at the wrist is almost simultaneous with the beat of the heart, which it could not possibly be if it were the flow of blood that caused it.

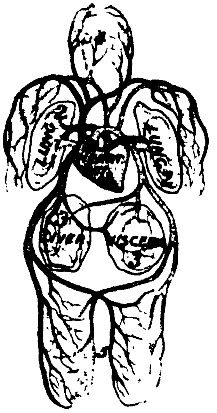
Besides its elasticity the artery has also the muscular coat, which in the smaller vessels adjusts the amount of blood to the state of the capillaries (whether open or shut), so that there may be no sudden block. This nice adaptation of the size of the vessel to the amount of blood in it is called "tone," and the loss of tone in an artery shows either languor of central controlling power (nerve exhaustion), or failure of elasticity (age, disease, etc.), or the formation in the arterial walls of hard plates (gout, etc.), all interfering with the regularity of the circulation.

The pulse is not only at the wrist, but wherever an artery is near enough to the surface for the wave of the pulse to be felt or seen, as at the temples, the ankles, etc.

We may just state that generally the influences that slow down the circulation are cold, digitalis, and the pneumogastric nerve, whereas heat, atropine, and the sympathetic nerve accelerate it. The vaso-motor nerve opens and closes the capillaries, and these act harmoniously, not only with arteries, but with the nerves controlling the heart.

The Vascular Glands. As indirectly connected with the vascular system, we may here consider the vascular glands, which include the spleen, the thyroid and the thymus glands in the thorax; and the suprarenal capsules above the kidneys.

The *spleen* is about the size and shape of the palm of the owner's hand, and is situated beneath the ninth, tenth, and eleventh ribs in the left side beneath the diaphragm. Its convex side is outward and its concave is in close proximity with the tail of the pancreas. It is of a deep red colour, full of blood, and weighs about half a pound. It is credited with many functions, one being that of a storehouse of peptones, and



57. DIAGRAM SHOWING THE FIVE COURSES OF THE CIRCULATION

(1) Round the heart, (2) to the lungs, (3) in the digestive organs, (4) in the brain, and (5) over the body. Dark shading, venous blood. Light shading, arterial blood

there is no doubt that a storehouse is sorely wanted by great meat-eaters. The red corpuscles of the blood are also said to be born here and introduced into the blood in great numbers, and then broken up and taken out when they want to die. The spleen is greatly enlarged in ague and other diseases.

The *thyroid gland* consists of two lobes, united by a band and lying in front of the larnyx, or throat. It weighs normally 1½ ounces, but, like the spleen, may be greatly enlarged in disease. It contains a gummy material, the purport of which is not readily ascertained. When it is diseased, the mental faculties seem affected. The Derbyshire neck or goitre is an enlargement of this gland.

The *thymus gland* is an inch long, lying lower down at birth on each side of the windpipe, but disappearing very early in life. It may form red corpuscles, like the spleen.

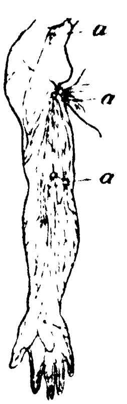
The *suprarenal capsules* are two small bodies like cocked hats, one on the top of each kidney, and seem to serve a remarkable purpose. The extract obtained from them has a marvellous power of contracting capillaries and stopping the flow of blood, and is now extensively used in arresting hæmorrhage. Its power is wonderful, and we have nothing so efficacious in drugs. When these suprarenal capsules are diseased the whole skin gets the colour of bronze. There is no doubt that they exercise a powerful influence over the economy of the body, and further discoveries may tell us exactly what this is.

The Lymphatic System. We now turn to a brief description of the lymphatic system, a small portion of which only has been touched upon in describing the digestion of fat.

It will be remembered that at the outset we pointed out that, as beneath our streets are three sets of pipes conveying gas, water, and sewerage, so throughout the body are three descriptions of vessels coloured by the fluid they contain red, blue, and white. The red and blue we have considered—they convey the arterial and the venous blood. The white or colourless are the lymphatics, which form a system almost as large as the true vascular system, of which they are an appendage, and with which they are everywhere connected. We must understand, then, that within the whole of the tissues of the body surrounding all the capillaries, and existing wherever there are no blood-vessels, is a vast network of tubes containing the liquid drainage of the body, which flows through all those vessels, always towards the heart. The lymph capillaries collect into large lymphatics, and eventually enter two trunks, the right thoracic duct, which is small, and the left thoracic duct, which is very much larger, and which carries all the fat from the food; these enter the veins on each side of the root of the neck. Just as all the body cells and tissues are being continually irrigated by capillaries, whose thin walls allow the fluid to ooze through, so they are constantly being drained of the surplus fluid by the lymphatics [58].

Besides this general use, the lymphatics have at least two other special functions.

1. They act in the intestines by the agency of the lacteals as absorbents of "fat" food and in the formation of chyle.



58. THE LYMPHATIC VESSELS IN THE ARM

(*a*) Lymphatic Glands

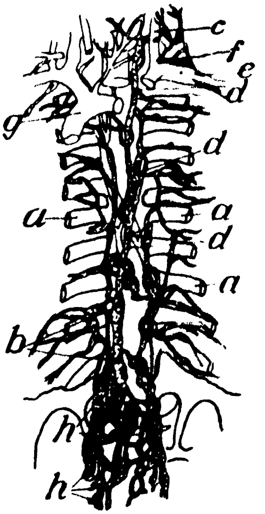
2. In some tissues they form the sole source of nourishment, as in the cornea of the eye, and in many connective tissues, which have no blood circulation.

The whole system may be regarded as a necessary appendage to the vascular system, although we have treated part of it under the head of absorption in order to complete the history of food disgestion.

The lymphatics that commence as capillaries round the blood-vessels have very thin and irregular walls, and often appear mere channels hollowed out in the surrounding tissues.

The lymph is the agent in conveying the oxygen and food from the blood capillaries, which they surround, to the body cells, as well as in conveying the major part of the excreta, CO_2, urea, etc., from these into blood.

Movement of the Lymph. The movement of the lymph towards the heart is first due to muscular pressure and very numerous valves. The collapsible lymphatics, whether amongst the voluntary muscles of the neck or the unstriped muscles of the intestine, have their contents therefore propelled in one

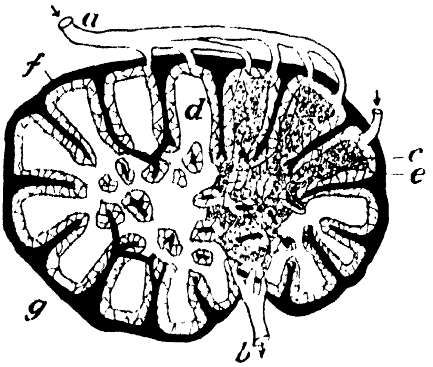


59. THORACIC DUCT

(*a*) Ribs; (*b*) receptaculum chyli; (*c*) left jugular vein; (*d*) trunk of thoracic duct; (*e*) left subclavian vein; (*f*) junction of these two veins, showing entrance of thoracic duct; (*g*) superior vena cava; (*h*) lymphatic glands direction. A second force is the direct act of the muscles surrounding each lacteal in the villi, by which, when full, their contents are ejected into the vessels beneath, valves again preventing their return. A third force is the inspiratory movement of the chest (as in the veins) which both squeezes fluid into the lymphatics and sucks the fluid of the large ducts into the blood-stream.

The lymphatics of the body, with the exception of some on the right side, but including all the lacteals, discharge their contents—after passing through numerous lymphatic glands en route—into a large reservoir about 2 in. long, called the *receptaculum chyli* [59] lying in the abdomen at the lower part of the spine on the left side. From here a stout tube, as thick as a goose-quill and about 18 in. length, called the *left thoracic duct*, leads right up the left side, and empties its contents at the juncture of the neck and arm (jugular and subclavian veins), thence to be carried to the right side of the heart.

The Police of the Body. Nearly all the lymph before entering the blood has to pass through one or more lymphatic glands. These are found in great numbers in the trunk of the body, in the neck, armpit, and groin, but not further down the limbs than the elbow or knee. These glands are somewhat the shape of small beans, lying right across the path of the lymphatics, with the convex side outwards or downwards, along which the lymphatics enter, while the lymph leaves it at the hilum, or depression, on the other side by one or two larger vessels [60].



60. SECTION OF A LYMPHATIC GLAND

(*a*) Afferent, (*b*) efferent lymphatics; (*c*) lymphoid tissue; (*d*) cortical substance; (*e*) lymph-path; (*f*) fibrous capsule sending in divisions into (*g*) the substance of the gland

The lymphatic glands exercise most important functions in the economy. They may be said to represent the police of the body, and every suspicious substance that enters the body finds its way to them sooner or later, and is there detained.

They stop, as far as they are able, the circulation of all poisons in the system; but for them a poisoned finger would infallibly infect the whole body. Yet, thanks to a small gland at the bend of the elbow, or, if this fail, the extensive chain of glands in the armpit, the poison is arrested and destroyed. We are constantly poisoning ourselves in small ways, and many of the poisons would spread and become fatal were it not for the action of these glands. Sometimes the head or throat, or ear or mouth is poisoned, and then it is that the poison is arrested and stopped and the life is saved by the lymphatic gland in the neck or throat; the glands swell and get painful, and we feel the lumps, which tell us the glands have done their work well. They are arranged all over the body at what may be called strategic points, and their value cannot be exaggerated.

In cancer of the breast, for instance, in the early stages when the poison is slight, it is stopped from entering the blood-stream by the glands in the armpit, which receive and destroy the poison, becoming enlarged and inflamed in the process. Should, however, the poison be allowed to progress undetected, there comes a time when its volume becomes too great, and it gets past them into the blood, and is there carried all over the body, and other centres of cancer are formed.

These lymphatic glands are filled with white corpuscles, similar to those in the blood, and it is these that destroy the poisons by breaking them up and reducing them to their elements.

All the drainage of the body, therefore, before it is poured into the blood, is carefully purified.

Before finally leaving this question of the circulation, we will give seven points that prove the truth of it—for this has often been doubted.

1. In half an hour the heart ejects more than the whole blood in the body.
2. Blood spurts from a cut artery.
3. The arteries are empty and the veins full after death.
4. If a limb be tied tightly with string, it becomes pale, because the arteries are compressed and blood cannot flow in; if tied slackly, it is swollen, because though blood can flow in, it cannot flow out.
5. The presence of valves in the veins.
6. Poison and aniline dyes are found to circulate.
7. The circulation can actually be seen during life in the web of a frog's foot.

Continued

FORAGE AND OTHER FARM CROPS

Lucerne, Sainfoin, Vetches, Clovers, Cabbage, Rape, Maize, Hops, Flax, and Hemp. Cultivation of Farm Crops

Group 1
AGRICULTURE
8

Continued from page 945

By Professor JAMES LONG

FORAGE CROPS

Lucerne. *M. Sativa* (Nat. ord., *Leguminosæ*; genus, *Medicago*), known as alfalfa in America, is a perennial, the roots of which have been traced to a depth of from 20 to 30 ft., for which reason on suitable soils it ignores drought [p. 881]. Lucerne is one of the very best forage crops; it produces superb hay, and may be cut four times annually after the first year, and until it has been overcome by weeds, which in course of seven years or so usually destroy the plant. Lucerne demands a dry, deep soil containing lime, and a mild climate; hence it is not grown in the North of England. It is a handsome plant, with a purplish-blue flower. It is sown with a corn crop in spring, 15 to 20 lb. of seed being drilled per acre. If broadcasted, more seed is required, but the plant is not so satisfactory. The weight of the seed is 64 lb. to the bushel. A useful crop will cut from 15 to 30 tons of green fodder, while as much as 5 tons of hay have been taken from an acre. Lucerne is occasionally mixed with grasses sown for a three or four years' ley, or permanent pasture.

Sainfoin. *O. sativa* (*Onobrychis*) is a handsome perennial, with a showy pink flower and a leaf with many leaflets [p. 881]. It is chiefly sown in the south on substantial chalky soils and other soils containing lime. Its roots penetrate to a great depth; it resists drought, and may last a few years. Sainfoin is a splendid green fodder, and is much employed for sheepfolding. The hay is equally approved by farmers, and is most valuable for horses and cattle. Sainfoin is usually drilled, the seed employed being either in the husk or removed from it by a process of milling. The seed required per acre is 50 lb. when milled, or 4 to 5 bushels in the husk. Milled seed weighs 62 lb. per bushel, seed in the husk about 25 lb.

SAINFOIN SEED

Vetches, or Tares. The vetch (*Vicia sativa*) is an annual grown in all parts of the country on most soils [p. 881]. It is sown at the rate of from 3 to 4 bushels per acre, the seed weighing 64 lb. to the bushel, either alone or with a cereal, preferably rye or oats. The mixture improves the feed, and the cereal plant keeps the vetch off the ground. Vetches are cut green for stock—especially horses—fed off by sheep folded upon them, employed for ensilage, and occasionally made into hay. There are two sub-varieties, the winter and the spring vetch, the former producing a very early cut of green food, while the latter provides forage during autumn, when it is often much needed. A green crop may weigh 10 to 14 tons per acre, while a dried crop may reach 30 to 40 cwt. The seeds number about 8,000 to the lb. The vetch is hardy, it responds to manure, and overcomes many weeds by its propensity to smother them.

Crimson Clover. Crimson clover (*Trifolium incarnatum*) is an annual, largely grown by the southern farmer for sheep feeding, and sometimes for hay [p. 941]. It suits most soils, upon which it is sown after the removal of a corn crop, the surface being well harrowed, and the seed broadcasted and covered with harrows and rolled. Ploughing for this crop is not advisable. Trifolium, of which there is a *white* variety (*T. album*), is really a catch crop, coming between a cereal and roots, or any other suitable crop which can be sown after its removal. It provides one of the earliest green fodders. The seed is sown at the rate of 12 to 20 lb. per acre, and weighs about 66 lb. per bushel, a green crop reaching 10 to 12 tons per acre.

Cabbage. *Brassica oleracea* (Nat. ord., *Cruciferæ*). There are different forms as there are several varieties of the cabbage tribe, including, as examples, the round-headed, big-hearted drumheads, the savoys, the loosely headed kale, or thousand-heads, and the flowering-hearted cauliflower. Although with good cultivation the cabbage will thrive on comparatively light soils, it prefers strong land, rich in nitrogen and phosphates. It responds best to dung and nitrate of soda, sometimes with an addition of salt. Field cabbage, which is a hardy biennial, like all members of the family, bears a yellow flower. Although frequently drilled, all the varieties of cabbage may be raised in seed-beds and transplanted. By adopting this method the plant will provide succulent green food for stock throughout at least six months of the year. The hardier members of the family are the kales, which are less damaged by frost and rain. Thousand-headed kale, grown largely for sheep, will produce a second crop after its foliage has once been consumed. The space required per plant is from 3 to 9 sq. ft., according to the variety and its size. The seed required to produce the plants for an acre is 1 to 1½ lb., or 3 lb. per acre when drilled. There are about 125,000 seeds to the lb., the weight of a bushel varying from 50 to 56 lb. A crop of drumheads should reach 25 to 35 tons to the acre.

Rape (*Brassica campestris*), like kohl-rabi and the cabbage, belongs to the natural order *Cruciferæ*, and is descended from the same stock. Rape is seldom sown in spring; it is chiefly a summer-sown crop intended for feeding sheep which are folded upon it, for ploughing-in as a green manure, or for smothering the weed crop. It is sometimes associated with mustard, the seed being mixed, and the two plants grown together with the same objects. The giant variety is most suitable for rich or well-manured soils, producing a great weight per acre, from 15 to 20 tons. The seed of the smaller variety is usually sown on chalks and the lighter soils; the quantity broadcasted is *12 lb. per acre, its weight being from 50 to 54 lb.* per bushel, the number of seeds in a lb. reaching nearly 120,000, while the yield of seed per acre should reach 30 bushels. Rape is often employed as a catch crop, whether for ploughing-in or feeding sheep, especially after the removal of an early crop of potatoes, being cleared off the land before the succeeding green crop is sown. Although rape will transplant, the practice is not common. The seed of rape, after pressing out the oil (colza), provides the residue from which rape-cake is manufactured.

THOUSAND-HEADED KALE

Mustard. There are two species of this plant—*Sinapis alba* and *S. nigra*. The former (white mustard) is that grown for forage, sometimes alone, often in combination with rape. It is, however, frequently employed as green manure, the crop being ploughed in. White mustard will produce 12 tons or more per acre on the richest soils. It is sown at the rate of 14 lb. per acre, the seed weighing 50 to 56 lb. per bushel, a pound containing over 70,000 seeds. *S. nigra* is grown for the production of mustard for the table.

Maize. (*Zea Mais.*) An annual cereal plant employed in many countries as green forage, and, especially in America, for conversion into ensilage for the winter feeding of cows. Maize grows luxuriantly in the warmer parts of England, while excellent crops have been grown as far north as Cheshire and Lincolnshire. It is a robust, tall plant, its height depending entirely upon the richness of the soil and the variety and quantity of seed used. It revels in hot weather, and during a warm, moist autumn evening it may be heard to grow—we refer to the popping of the immature leaves through the joints of the stem. Maize prefers medium deep soils, richly manured, especially with dung and phosphates. When broadcasted with 3 bushels of seed per acre, the plant grows thickly to a height of 3 to 4 ft.; when drilled or sown by hand in alternate furrows after the plough, 1½ bushels being used, the plants are much stouter, and will grow to a height of from 7 to 9 ft. The seed weighs about 60 lb. to the bushel, and will produce from 15 to 40 tons of fodder per acre. The lowest temperature of germination has been noted at 49° F. The table below illustrates the value of green maize as a stock food.

Among other feeding crops which are grown upon a small scale, but which are not regarded as farm crops are chicory, prickly comfrey—which is difficult to eradicate for a succeeding crop, and which, if abundant, is a poor forage—and the Jerusalem artichoke.

It may be pointed out with regard to all the plants which have been mentioned that while there is necessarily a limit to the weight of fodder which can be produced, the average crop grown in this and other countries is much smaller than is possible. Large increases are obtainable by high cultivation, and especially is this the case with lucerne, cabbage, rape, vetches, and maize. Given suitable soil and first-rate preparation, good seed and adequate manuring will be followed in four years out of five by very large additions to the crop

	Yield per acre fresh material.	Dry matter.	Dry matter per acre.	Digestible dry matter per acre.
	lb.	per cent.	lb.	lb.
Lucerne	35,000	25	8,750	5,162
Maize, whole plant	30,000	25	7,500	5,025
Red clover, about 3½ tons new hay	18,000	30	5,400	3,070
Oats and peas	20,000	16·2	3,240	2,106
Mangels	60,000	10	6,000	5,200
Potatoes	18,000	25	4,500	3,825

OTHER FARM CROPS

The Hop. The hop (Nat. ord., *Urticaceæ*; genus, *Humulus*) is produced from one species, *H. lupulus*. It is a perennial, diœcious plant—*i.e.*, the male and female flowers grow upon different plants, hence the importance of ensuring the plantation of a sufficient number of male plants. The hop prefers a rich, deep loam, well furnished with lime. The soil should be clean, thoroughly cultivated, both before and during the years of production, and heavily manured, not only with manure readily available, but with fertilisers, which gradually liberate plant food. The slow-acting manures employed include shoddy, rape dust, and horny matter. The hop is produced from cuttings which are planted on hills at equal distances apart. The cuttings—which are grown in different varieties—the cost of preparation, planting, poles, and string, along which the hop-bine twines, together with the picking and drying in the kiln, make this plant an expensive one to produce. As hop-growing is a somewhat risky industry, it is not surprising that it is costly in the market, and that growers are alternately elevated and depressed. An average crop is from 6 to 7 cwt., but the yield may be much more or much less. Hops are sold in "pockets," or sacks, of a given size, which contain 1½ cwt.

Flax. This plant (Nat. ord., *Lineæ*; genus, *Linum*) is grown in one species, *L. usitatissimum* [p. 881]. Flax prefers a rich soil with a fine deep tilth, and is not grown with success on clays or thin chalks and gravels. It is grown either for the seed or the fibre. The seed is chiefly produced for the oil, which forms more than one-third of its weight, the residue, after oil extraction, being pressed into cakes, which are used for cattle, and which contain 10 per cent. of oil. The straw, which is pulled before the plant seeds, is prepared, when fibre is required, by steeping. When grown for the seed or grain, 1½ to 2 bushels of seed are drilled per acre; when grown for the straw, 2½ bushels are drilled, the bushel weighing 52 to 56 lb., 1 lb. containing about 100,000 seeds. A ripened crop of linseed produces about 2 to 2½ quarters per acre, and from 35 to 40 cwt. of straw while the fibre produced varies from 5 to 8 cwt. per acre.

Hemp. The hemp grown in this country is of one species, *Cannabis sativa*, a diœcious plant; it thrives best on a rich, mellow soil of deep tilth, finely cultivated [p. 881]. The quantity of seed drilled is one bushel to the acre, a bushel weighing about 40 lb. It should contain about 30 per cent. of oil. The crop reaches some 2 quarters of 8 bushels, with 40 cwt. of straw; the weight of fibre varies from 6 to 8 cwt. per acre.

CULTIVATION OF FARM CROPS

It is the custom among farmers to grow the various crops on the arable land upon a system of rotation. It will be well to explain not only what that system is, but the principles upon which it is based. It is a commonly accepted maxim that it is bad farming to grow two white straw crops—by which we mean cereals—in succession on the same land. Highly skilled farmers, however, are able to grow these crops from year to year in absolute succession with most excellent results by maintaining the cleanliness and fertility of the soil. The rotation system, however, is to be preferred. It enables the farmer to produce greater variety of plants or crops, to maintain stock, such as cattle and sheep, and thus to produce abundance of farmyard manure, which is practically impossible where the land is employed, however skilfully, for the production of grain crops alone. The rotation system not only preserves, but promotes fertility. If a cereal crop is taken from year to year, it becomes necessary to provide manures containing nitrogen with great liberality, but although phosphatic manure is essential for some time, mineral fertilisers collect in the soil to a greater extent than they can be utilised for want of some other crop which would draw upon them.

Fertilisers for Cereals. Nitrogen is the dominant fertiliser of the cereals, phosphoric acid of turnips, and both phosphoric acid and potash of the pulses, clover, and other leguminous crops. If, therefore, we alternate these crops upon a recognised system, we enable one to feed upon the residue of fertility left in the soil by another, and in its turn to provide something for the crop which succeeds it. When a grain crop succeeds clover or beans, it is enabled to draw upon the store of nitrogen which these plants have extracted from the atmosphere and left in their roots. When the soil has been exhausted of available phosphoric acid and potash, it is once more supplied with these materials through the medium of such fallow crops as the turnip or the potato, both of which it is usual to manure with liberality, and, under good farming, with dung as well as artificial fertilisers.

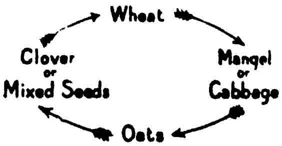
In a rotation a grain crop usually succeeds both the mangel and the potato, and is thus provided with what it requires, although in many cases it may still be advisable, where farming on the intense principle is followed, to give dressings of both phosphatic and nitrogenous manures. This is the more necessary for the reason that, under the four-course system of rotation, clover, or a mixture of one or more varieties of clover and rye grass, or of mixed grasses, is sown in spring with the growing cereal, to become in its turn a crop for feeding or mowing in the following year. The demand for food is therefore considerable, hence the importance of adequate preparation.

Value of Rotations. There are, however, other reasons why a system of rotation is advisable. By no other method is it possible to maintain the land in a clean condition—in a word, to destroy weeds. This cleaning is effected where plants, such as the mangel, the swede, the potato, the cabbage, kohl-rabi, or beans, are grown in rows sufficiently wide apart that the horse-hoe may be employed between them and the hand-hoe in the rows of plants themselves. Crops like the turnip or the cabbage, being frequently eaten off by sheep, indirectly improve the lighter soils, for the manure which is dropped adds fertility, while the compactness which follows the herding of the flock ensures a more perfect seed-bed. Again, the rotation system enables the farmer to keep within limits the ravages of insect and fungoid parasites, which are the cause of so much destruction. The crop being changed, the enemy, whose attacks are confined to a particular variety, practically finds its occupation gone; whereas if a crop which has been seriously attacked—as the turnip with the fly or with the fungoid disease known as anbury—were grown again upon the same field within one or two years, the probability is that the damage would be more serious.

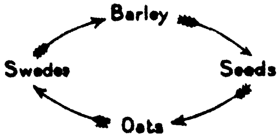
Prevention of Weeds. This question, however, like that referring to insect and other pests, will be dealt with in succeeding chapters. The better the cultivation, and the more liberal the manure, the fewer the weeds and the heavier the crops. Indeed, with heavy cropping, weeds have but little chance of arriving at maturity, while the material available for the production of dung becomes greater and greater in quantity. It is of prime importance, however, to prevent the seed of weeds, or even of cultivated plants, finding its way into the manure of stock, as, for example, the seeds of hay, which are so commonly found in the manure of the stable and the cow-house. Grass seeds conveyed to the soil with dung intended for feeding any other than a grass crop simply produces abundance of weeds, for grass is a weed in any but a grass field. For a similar reason, home-produced grass seed, as the sweepings of a loft, should not be employed on the farm owing to the fact that it contains weed seeds, which are only removable by the machinery of the seedsman.

The following diagram will suggest two methods of rotation:

HEAVY SOILS



MEDIUM SOILS



In that which is suitable to the heavier classes of soil, mangel or cabbage may follow wheat, and be succeeded by oats, or even by barley, where this plant can be grown with success. This corn crop may be followed by clover, or a mixture of clover and grasses, the seeds having been sown with the oat or barley crop, to be followed again by wheat, for which they have prepared the way.

Where it is inconvenient to take wheat—which is an autumn-sown crop, although under bad conditions sowing is sometimes delayed until nearly Christmas—oats may be taken, and where the necessary ploughing becomes impossible owing to bad weather, wheat sowing is abandoned, an oat crop is usually taken after ploughing the land later on.

Systems of Ploughing. The system of ploughing adopted by a farmer depends chiefly upon the soil, but largely upon custom. Deep ploughing should never be resorted to where the subsoil is brought to the surface. It is important, however, to plough as deeply as possible without harm in this direction for all fallow crops. Deep ploughing, too, makes the soil more porous, and paves the way for shallow ploughing in the case of most succeeding crops, which are in consequence more quickly started in life.

The dung produced upon the farm is usually employed for the wheat, mangel, and potato crops, but on many occasions land is also dunged for swedes, cabbage, rabi, and maize. The fertility of dung is not all utilised by the crop for which it is provided, a portion remaining for the benefit of succeeding crops.

In the rotation designed for the lighter soils, seeds are sown with the barley crop, which succeeds swedes which have been eaten off by sheep. The feeding of sheep on the land enriches the top three or four inches of soil, through which the roots of barley ramify in search of food. Assuming that the swedes have been grown by the aid of superphosphate, and that the sheep have also received cake, corn, and hay, it follows that the manure which they drop, both liquid and solid, not only contains a large proportion of the phosphates which were distributed on the soil for the benefit of the swedes, and which they have consequently taken up, but the fertilising constituents of the artificial food.

It is not surprising, therefore, that even poor, thin soils, such as those resting on gravel and chalk, are enabled to produce heavy crops of grain and straw, and to retain a sufficient residue of fertility for the benefit of the clover or mixed seeds which are cut in the succeeding year. In many large sheep-breeding districts these seeds, which may embrace sainfoin, sown alone, are, like the swedes, consumed by sheep receiving cake and corn, and thus the land is once more doubly enriched for the benefit of a succeeding oat crop, which many advanced farmers would assist with a dressing of such an artificial manure as sulphate of ammonia. This manure, on light soils, is preferred to nitrate of soda, owing to the fact that it is much less soluble, and, consequently, not so likely to be lost in the drainage water.

Four-course Rotation the Best. There are other rotations employed by farmers in various parts of Great Britain, but the four-course, or Norfolk rotation, to which we have specially referred, is the best foundation which can be laid. The greater, however, the grasp of principles, the better able is the farmer to form a rotation for himself, should he desire to make any change. Such a man will be able to take "catch" crops, to which we shall presently refer, and to supplant one crop for another, or even to allow his clover mixture or seeds to remain a second or even a third year before ploughing up for a succeeding grain crop.

Continued

Continued from page 1138

ROME: GROWTH OF THE DEMOCRACY

Growing Power of the Plebeians. The Decemvirate. Frontal Wars. King Pyrrhus of Epirus and his Triumphs. Roman Colonisation. Carthage

By JUSTIN McCARTHY

THE cause of the Plebeians was gradually growing stronger. The renewed severity and energy of the attempts made to force the Plebeians into submission only proved that their opposition was at last becoming formidable, and gave them a fresh impulse towards organised and determined agitation. The result was that the Plebeians at last obtained better terms of citizenship, such as the right to sit and vote in the public legislative assemblies, on conditions approaching more nearly to equality between class and class. The public assemblies consisted of a Senate and a sort of representative chamber, both of which had been practically under the entire control of the Patrician order, until the agitation among the Plebeians and the coming up of the spirit of reform began to compel some constitutional changes.

Proposed Codification of Laws. Meantime, the Patricians had kept the whole legal system, such as it was, under their own control, and actually in their own hands. There was no written code of laws, nor was there any tribunal of appeal against a sentence passed by any existing court—unless, indeed, where a sentence of death had been passed, when an appeal was allowed to the general assembly of the Republic. The very existence of such an exceptional right of appeal is distinct evidence that Rome was already emerging from that condition in which absolute power can be held by any ruler or by any order. Terentilius, one of the Tribunes, brought forward a bold project of reform He proposed that a commission should be appointed to prepare a full code of laws for the government of the State—a codification of the laws at that time existing, and of the new laws which ought to be devised and brought into operation. The Patricians resisted the proposed change, and more than ten years passed before anything was done to bring about the reform.

The "Decemvirate." The interval was one of increasing organisation among the Plebeians, and at length it became clear that if the Patricians did not give way the result must be civil war. At last the Patricians yielded to the agitation, and ten men were chosen to prepare the new code. These men were called the Decemviri ("Ten men"), and to them was assigned, for a year, the whole government of Rome, during which time the new code was to be brought to completion. The laws which they prepared were finally accepted—willingly by the Plebeians and unwillingly by the Patricians. They were written on ten metallic tables and set up in the place where the legislative assembly used to hold its sittings.

During a second Decemvirate some other laws were added, and two more tables were accordingly set up. Five of the Decemviri were Plebeians and five were Patricians. When the Decemvirate had come into power it soon began to be seen that the Patrician and Plebeian members were alike unwilling to give up their official positions, and it appeared highly probable that this council of ten were determined to maintain their places, and to rule the State as a permanent authority, to the exclusion alike of the Consuls and the Tribunes, to whom for a long time both orders of the community had submitted. This apparent creation of a new despotic power began to be less satisfactory to the Plebeians than even to the Patricians.

Virginia and Appius Claudius. In the meantime, Rome had become engaged in a war against her Sabine and Volscian neighbours, and a great mass of the soldiers suddenly withdrew from the field of battle and assembled at a vast gathering—at what would now be called a monster meeting—in the centre of the city, and demanded the restoration to power of the popular Tribunes, who represented the interests of the people. To this period belongs the thrilling story of Virginia, which has been made popular by poets, romanceists, and dramatists in all languages of the civilised world down even to our days. The story is that one of the Decemvirs, Appius Claudius, who had been raised to his position because of his ability and public spirit, and who for a time continued to make himself popular, began at last to prove that he aimed at becoming an absolute despot. He was suddenly inspired with a passion for a beautiful Roman girl, Virginia, daughter of Lucius Virginius, a Plebeian who was serving in the Roman Army. Appius Claudius claimed a right to take possession of the girl on the ground that she was the daughter of one of his hereditary slaves This claim was resisted by the young woman's father; but a sort of sham trial, got up by Appius Claudius, gave as its judgment that she was actually a slave Then her father, to save her from dishonour, stabbed her to the heart in the presence of the crowd assembled to witness the trial

A Dramatic Ending. A feeling of horror went through the whole public at the conduct of the Decemviri, the Army rose in support of the girl's father, and the immediate result was that the Decemvirate was overthrown, and Appius Claudius sent to prison, where, it was said, he committed suicide to save himself from death on a public scaffold.

It is impossible to know with any certainty whether the whole story, or any part of it, is true;

but we must attach some importance to the fact that the story did at the time obtain general acceptance, and that the events it told coincided with the epoch when, for whatever reason, the power of the Decemvirate was brought to a sudden end. The result was that Rome returned to the system of Consuls and Tribunes, elected according to the former arrangements.

New Laws. Laws were passed to ensure the inviolability of the Plebeian as well as of the Patrician magistrates, to prohibit the creation of any magistrate from whom there could be no right of appeal, and to give an equal share in the making of laws to Plebeians and Patricians alike. Not many years passed before the development of reform made itself manifest in a new and striking manner. A law was made which allowed of marriage between Patricians and Plebeians, and thus struck at the very heart of the whole legalised Patrician system by sanctioning, and therefore encouraging, those intermarriages between the orders, and the bringing into the world of families descended both from the Plebeian and the Patrician class.

An important struggle took place as to the conditions of the consular office. No Plebeian could, up to this time, be elected a Consul, and for many years there had been a popular agitation for the removal of the restriction. A definite proposal to this effect was made by one of the most popular among the Tribunes, and it was opposed for a while with vehemence by the Patricians. The contest was destined to end as most of the struggles between the oligarchic and the popular order had hitherto ended. A compromise was suggested on the Patrician side, and many of the Patricians welcomed the suggestion in the absence of any better way for getting out of the difficulty.

A Compromise. The suggested compromise was that, instead of electing Consuls, the public should elect military Tribunes, who were at the same time to be endowed with the civic authority of Consuls. The reason given for this somewhat curious proposal was that Rome, being then engaged in a succession of frontier wars, needed more than two generals to command her forces. Even when this so-called compromise had been accepted and made legal, in 494 B.C., the Plebeians continued to gain in strength, and they were able to carry the election of these military Tribunes in the majority of instances. It is well to notice the fact that during all these various elections many of the same influences prevailed on both sides which were common to elections in much more modern times, and that bribery, intimidation, liberal promises, serious threats, and the secret purchase of votes during canvassing were freely exercised in order to obtain for the more powerful agitators, the majority of votes for their chosen candidates.

The Plebeians were becoming more expert in organisation, and at last became so successful that when the Consulships were restored, the Plebeians succeeded again and again in electing one of their own order to Consulship. The time soon came when all magisterial offices were thrown open to Plebeians and Patricians alike. The Patricians thus continued to lose privilege after privilege, and the Plebeians were beginning to be even richer as a class than those who had been their former rulers and masters.

In surveying this prolonged struggle, it will be seen that we cannot possibly regard the Patricians as a class animated merely by selfish motives and a desire to oppress their humbler fellow-citizens; nor can we look upon the Plebeians as entirely animated by an unselfish and patriotic love of liberty and equality. The whole struggle was in its nature and character very much the same as that which has gone on among all peoples rising into civilisation during the history of the world.

A Prolonged Struggle. The landed class has been brought up to believe its own order providentially endowed with the right to rule, and the lower classes have not unnaturally been inclined to regard themselves as the victims of selfish tyranny. In the nature of things the poorer classes grow, with the increasing opportunities which developing civilisation brings, into the capacity and opportunity for earning more money, for becoming traders and merchants instead of remaining mere tillers of the soil; they thus become the possessors of land for themselves, and are all the better able to hold their own against their social superiors.

This was, of course, a new story in Rome, but it has become a very old story in our days. The Roman Patricians and Plebeians were just what their early conditions made them, and either set of men put, in the beginning, in the place of the other would have acted, in all human probability, much the same part as that which was taken by the other.

For a long time after the creation of the Tribunes the same struggle went on between Patricians and Plebeians. The Plebeians were striving unceasingly for civic equality in politics and for a reform in the land tenure system, and the Patricians as obstinately fought against all such levelling projects. Many times there appeared in the Patrician ranks some man of more advanced views and more generous instincts than those of the majority of his fellows, who strove for agrarian reform and political equality. One of these enlightened reformers, Spurius Cassius, who had distinguished himself in his really patriotic efforts, was tried on some absurd charge of striving to make himself actual ruler of the State, was found guilty of the charge by a court under Patrician influence, and was put to death. His death, as often happens in the case of a patriot condemned for having striven in the cause of public reform, only served to call into existence other men inspired by his example and willing to risk much for the same cause.

The Old Story. Some of the Plebeians who had made money were drawn to side with the Patricians, in the hope, no doubt, of thus rising in the world. These men often lent their support to prevent their own order from succeeding in the effort after equality and land reform. The Plebeians, however, continued to win "all along the line." But in the meantime there were almost unceasing wars going on, and these wars tended inevitably to withdraw public attention from the struggle for domestic reform, and to make success in battle the great object and glory of the State. In all countries which are only as yet developing their civilisation, and have not permanently settled their form of government, such wars must naturally lead to the adoption for the time of some form of dictatorial power, and this tendency was already clearly manifesting itself in Rome.

Frontier Wars. The history of Rome had been almost from the founding of the city a history of continuous wars. The whole of Italy was divided into separate States, some of which were peopled largely by invading foreigners, and throughout the entire country there was no feeling of common nationality. When the Romans began to found a State of their own they had to accomplish their work to a great extent by intruding on the State of their neighbours; and when Rome had become thoroughly established and recognised as a Power, it stood out distinctly as an individual State in Italy; as France or Germany now does in Europe. There were frontier wars almost incessantly going on, begun by neighbours who desired to occupy some of the territory of Rome, or by Rome desiring to have and to hold some neighbouring land. The period following the rise of the Plebeians to political and civic emancipation and equality was made memorable by some of the greatest wars recorded in the history of Rome. It was beginning to obtain a complete supremacy in Southern Italy, where many Greek populations had long become established. This position, however, was not obtained until a most momentous and severe struggle had been brought to an end.

Pyrrhus, the Famous King of Epirus. One of the most famous sovereigns of those times—indeed, one of the famous sovereigns of the world—was Pyrrhus, King of Epirus, then, for the most part, an Asiatic realm. Pyrrhus had extended his dominions by his conquests in Western Macedonia, and in the year 280 before the Christian Era, the Tarentines—a Grecian colony in Southern Italy—implored his help against Roman invasion. Pyrrhus agreed to undertake the work of defence, and he sailed with a considerable army and a large number of elephants for the Italian shores. His first battle was long and fierce, and he lost in it a large number of his fighting men; but he won an unquestionable victory, mainly because of the presence of elephant allies—creatures such as the Romans had never seen before and against which they did not well know how to contend.

Pyrrhus seems to have well understood the nature of his victory, for tradition reports him to have said that after one other such victory he must have to return to Epirus alone. Some of the Italian States, who were growing jealous of the spreading power of Rome, became allies of Pyrrhus, and encouraged him in his northward march. He pressed on to within 20 miles of Rome, but there he found that the Roman preparations for defence were too strong for an attack with his remaining army. He fell back southward, and passed a winter in Tarentum, where he made his preparations for renewing the campaign.

Another Victory. He once more measured his strength with the Romans, and once again became victorious in the battle; but he was victorious at so heavy a cost that he found it necessary to withdraw for another interval to Tarentum and do his best to restore the strength of his force. A truce was agreed upon between Pyrrhus and the Romans, and Pyrrhus entered upon a new war-like enterprise. He went into Sicily to help the Sicilian Greeks against the Carthaginians, who were now becoming a formidable invading power endowed with a passion for conquest. Pyrrhus had much the same sort of fortune in Sicily as that which he had experienced in Italy. He began splendidly, but after a while received a severe repulse from the Carthaginians—a repulse which seems to have marred his calculations and dulled his hopes.

The Sicilian Greeks and he did not get on well together, and after a while he withdrew his forces from Sicily, with the object of again making war upon Rome. A serious mishap came upon him while he was crossing from Sicily to Italy. The Carthaginians attacked him with their navy and destroyed the greater number of his vessels. Pyrrhus was not a man to be discouraged even by heavy losses, and he went on with his attempts at the capture of Rome as if nothing had happened to diminish his military and naval strength. Again, the war god Mars, as would then have been believed, was against Pyrrhus. He sustained a heavy defeat at the hands of the Roman Consul, Curius Dentatus, and this ended his efforts to conquer Rome. He had to leave Italy and return to his own kingdom, Epirus, where he arrived with but a very small fraction of the army with which he had set out upon his expedition.

A Question of Supplies. Then a new difficulty presented itself. Pyrrhus was still the undisputed sovereign of Epirus, and still the commander of an army, but a perplexing question soon came up to trouble him—the question as to how he was to supply his army with food and clothing and weapons of war. His previous expeditions had already exhausted his resources, and there was not at that time, and in those regions, any loyal parliament to vote liberal supplies to the embarrassed ruler. No way of obtaining funds could suggest itself to the mind of Pyrrhus, except the undertaking of a new military enterprise which might end in the conquest of a foreign kingdom and the possession of ample spoils. He therefore undertook the invasion of Macedonia.

In this he was successful, and was created King of Macedonia. This was a position which he had already held as a youth during one of the conquests of Macedonia by the armies of Epirus, but his nominal rule over Macedonia only lasted for about half a year. Now that he was again King of Macedonia he led his armies against Sparta and Argos. His second rule as sovereign of Macedonia was not destined to last much longer than his first, for the Spartans defeated him in all his efforts to conquer them. True to the whole policy of his life, he immediately attempted an invasion of Argos, and there a fate befell him which we may believe would have been regarded by him as the most undesirable and the most unlikely close to his life of soldiering. He lost his life not on the battlefield, but by a stone or a tile thrown by the hand of a woman. The woman who brought to an end his varied military career saw him from her shelter on a housetop, and recognising him as the chief danger to her country, flung a heavy stone or tile at him, which struck him on the head and killed him.

Death of the Warrior Emperor. Pyrrhus was then in his forty-sixth year, and had reigned for some twenty-three years. According to all we learn of him from record and tradition, he was a good ruler over his own people, and over those whom he had conquered, except for his one ruling passion—the love of war and conquest. That one defect filled him with faults. During his few periods of peaceful rule he endeavoured to make his subjects happy, and he held advanced views of civil government and the equality of orders and classes. He was certainly one of the most brilliant soldiers of any time, and it was characteristic of him that no defeats or even successions of defeats ever brought to him a feeling of despair or shook his faith in his ultimate capacity to carry all before him. If soldiering could only be a religious faith, then Pyrrhus might be said to have lived and died in absolute devotion to his cause.

Roman Colonisation. After his death, Tarentum was handed over to the Romans, who levelled its fortifications and took possession of its fleet. Rome before long completed the conquest of all the Italian regions south of the Apennines and might now be regarded as the ruling power over the whole of Italy. It seems clear that the policy pursued by Rome was one aiming at the absorption of all the colonies which she had conquered into a willing submission to her rule and a desire for citizenship of the great rising State. Something like the sentiment of nationality was growing up throughout the Italian peninsula. "One Italy," the phrase so well known in our own times, had begun to be the motto and the prevailing desire of all the Italian populations which had been growing into self-ruling States. It is easy to understand how such a feeling must be stimulated in its growth by any attempt on the part of a foreign State to make herself the owner of Italian territory. Up to this time Rome had not made any effort to extend her dominion beyond the seas. She had not a great fleet, and was content with the construction of enough ships for the protection of her coasts.

Carthage. A new rival in power was coming into existence. In the recess of the Bay of Tunis, in the middle of the north coast of Africa, was the city of Carthage, which had been founded, as tradition tells us, by the Phœnicians of Tyre about a century before the building of Rome. The city itself is said to have covered an area of some fifteen miles in its most prosperous days. Poetic legend assigns the foundation of Carthage to Dido, the daughter of a Tyrian king—the Dido whose love for Æneas forms a thrilling episode in Virgil's great poem. Whatever may have been the origin of Carthage, it is certain that the city soon became the capital of a very powerful State. The Phœnicians had for centuries been a sea-faring race, and had established many ports and stations on all the seas within their reach. They were not warriors, but were animated by the spirit of travel and of commercial enterprise. They were by nature sailors and traders. They now proved themselves capable of brilliant war exploits as well; and, indeed, men who performed such daring explorations of seas hitherto unknown to them could hardly have wanted the courage which makes the soldier. Carthage soon became engaged in wars against some of her neighbours, and the result of these was that she found herself brought into rivalry with Rome. Rome felt an interest in some of the States against whom the Carthaginians made, or had to make, war, and the Romans set about the building of a fleet in order to enable them to contend against their maritime opponents. The Romans had the better in most of these encounters.

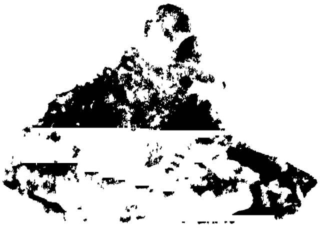
The Punic Wars. Then began those wars between Rome and Carthage which are known as the Punic Wars. A great soldier appeared among the Carthaginians, whose name will ever be renowned in the world's history. This soldier was Hannibal. He was the son of a famous Carthaginian general named Hamilcar, who had served with great distinction in the first Punic War. The story is told that while these wars were going on Hamilcar took his son Hannibal with him on one of his expeditions, and made him swear upon an altar eternal hostility to Rome. Hannibal was only eighteen years of age when his father fell in battle, and he seems to have kept ever in his mind the vow he had made of hostility to Rome.

He distinguished himself so much in the field that when he was only in his twenty-sixth year he was made Commander-in-Chief of all the Carthaginian forces. He is one of the first great military commanders known to history who succeeded in leading an army across the Alps in spite of the difficulties put in his way by the roadless mountains and their wastes of eternal snow. He marched directly towards Rome, and awaited the Roman army on the shore of Lake Trasimenus, a lake which the tourist can see from the windows of an Italian railway carriage. The Roman army was there completely defeated.

Continued

Iceland Spar (Calcium carbonate)
Showing double refraction [p. 768]

Calcite, or Calc Spar (Calcium carbonate)
In ordinary crystalline form [p. 768]



Calcite, or Calc Spar (Calcium carbonate)
In ordinary crystalline form [p. 768]

Quartz Crystal (Silica)
Probably coloured by manganese [p. 767]

Banded Agate (Silica)
[p. 767]

Banded Agate (Silica)
[p. 767]

Calcite, or Calc Spar
In tabular form [p. 768]

Meteoritic Iron
[p. 767]

Barytes, or Heavy Spar (Barium sulphate) [p. 768]

A GROUP OF TYPICAL MINERALS

Reproduced by Photography and Coloured from Nature

[See Geology.]

THE EARTH'S INTERNAL FORCES

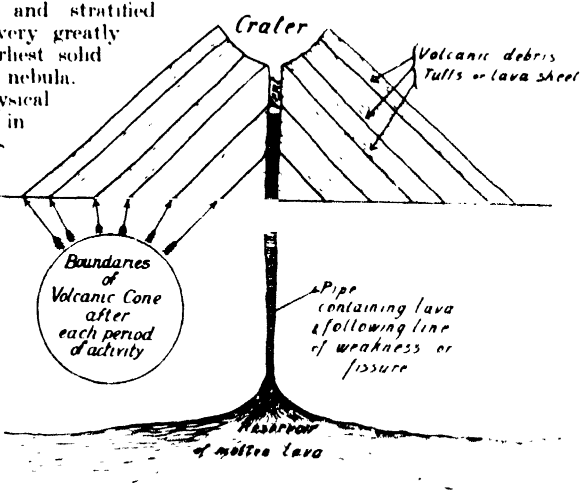
Processes of Change. How the Earth's Crust is Influenced from Below. Volcanoes, Geysers, Earthquakes, and how they are Caused and Studied

Group 14
GEOLOGY
6

Continued from page 107

By W. E. GARRETT FISHER

IN the preceding sections we have dealt entirely with *descriptive geology*. We have considered the constitution of the rocks and minerals which form the crust of the earth. We now come in due order to the consideration of *physical*, or *dynamical, geology*. By this is meant the study of the various natural agencies which have given rise to the state of matters which now obtains on the earth's surface. It investigates the processes of change which are now at work upon the earth, and also helps us to see how, in the far-distant past, they have modified the primeval rocks. We have already seen that the earth's crust, when it first solidified from its original molten condition, must have been composed entirely of igneous, or crystalline, rocks. We know that at the present day the greater part of the surface is covered with soil and stratified rocks, which are very greatly changed from that earliest solid product of the fiery nebula. The business of physical geology is to tell us in what way these changes took place.


Crater
Volcanic debris
Tuffs or lava sheets
Boundaries of Volcanic Cone after each period of activity
Pipe containing lava & following line of weakness or fissure
Reservoir of molten lava

36. DIAGRAM OF A SIMPLE VOLCANO

Uniformitarianism. The early geologists were in the habit of thinking that this beneficent change from the bare volcanic rocks and the fire-smitten deserts of the early world to the fertile fields which now grow ripe for harvest, and the kindly soil on which man lives and has his being, must have been due to some correspondingly extraordinary change in the order of Nature. They were always ready to evoke the aid of some gigantic cataclysm in order to explain the geological history of the earth. We are wiser nowadays, and find ourselves able to explain all these changes without going beyond the agencies which are still at work, both inside the crust of the earth and on its surface.

It is true that many of these agencies have been accustomed to operate in the past with far greater violence than they ever put forth in the present day. Our modern volcanic eruptions are trifling displays of fireworks when compared with the gigantic outflows of lava which produced many of the igneous rock formations of the earlier world. We know no such earthquakes as those which shattered and rent the crust of the earth while it was still thinly covering the subjacent abyss of liquid fire. Even the action of comparatively gentle agents like winds, rivers, and waterfalls is probably much slower nowadays than it was in the distant ages of the earth's history, as written in the fossiliferous rocks. The glaciers of the Alps and the Himalayas, even the gigantic ice barrier which defends the greater part of the Antarctic continent, are only a faint shadow of the ice sheet which once clothed almost the whole of Northern Europe. But though these agencies have lessened in degree, they are still the same in kind. The great doctrine of *uniformitarianism*, which was enforced by Sir Charles Lyell with all the weight of his genius, and is now universally accepted by geologists, teaches us that we need not attempt to explain the history of the earth by introducing any agents which show a marked difference from those which are at work to-day. Such convulsions of its surface as the earth has known still find their analogues in the processes of Nature, and were at the utmost only an exaggeration of the processes which we can watch in action at the present day.

Processes of Change. We all have a general idea of the *processes of change* which are now at work upon the rocks. We see the wind day after day sweeping up the dust from one part of the dry earth and heaping it up in another. We know that when the rain falls it converts this dust into mud, and often washes it away, leaving the surface of the fields or roads bare sheets of naked rock. The farmer and the gardener tell us how frost pulverises the soil and splits up stones and rocks. We cannot take a country walk without seeing how the little streams and rivers are continually washing soil away from one place and depositing it in another. An inexpensive excursion to Switzerland will familiarise us with the work of glaciers in chiselling out valleys, smoothing rock-surfaces like gigantic planes, and transporting vast boulders from their perches high up among the hills to perplex travellers in the valleys. Every holiday at the seaside shows us how the waves of the ocean are continually battering the shore, breaking down the hardest quartz rock into fine sand, and ever making deeper and deeper inroads upon the most lofty and imposing cliffs.

Internal Influences. We are less familiar with those agencies of change which are within the surface of the earth. In this part of the world, at any rate, we have no acquaintance with volcanic activity; and if an earthquake does come our way, it is so gentle that, as a rule, we only learn of its existence from the newspapers next morning. But we know from the reports of travellers in the tropics that volcanoes are still at work pouring out lava over the surrounding land, that earthquakes are still competent to swallow up whole villages, and open chasms, which seriously affect the surrounding strata. It is our business now to study the action of these various agencies as modifying the crust of the earth.

Hypogene and Epigene Agencies. We may divide these agencies into two classes for convenience of study, according as they operate above or beneath the surface of the earth. There is a fairly obvious distinction between the superficial agents which produce such changes as we mean when we speak of the weathering of rocks, and those subterranean forces which are the cause of volcanic activity, and give rise to earthquakes or to less perceptible secular movements of the earth. The subterranean agencies are called by geologists *hypogene*, while the superficial are known as *epigene*. Both these agencies, which do so much work upon the earth's crust, owe their existence to the same source of energy, being derived ultimately from the heat of the original nebula out of which the whole solar system has been developed. [See ASTRONOMY.]

The hypogene agencies, as may be readily seen, are mostly due to the heat still remaining in the interior of the earth. It is no difficult task to trace the association of volcanoes with the central fire, and we shall see later that earthquakes, and the slow secular movements of the earth's crust, are alike due to the fact that the earth has been slowly cooling since it first came into existence.

The epigene agencies owe their powers almost entirely to the heat of the sun, which is itself the residue of the original nebula. They are practically all due to movements of air and water, or to changes of the temperature, or to the action of life; and none of these could exist if it were not for the sun's heat.

Agencies of Change in the Earth's Crust. It will be convenient here to notice the various agencies of terrestrial change in tabular form before we go on to deal with them in detail.

1. HYPOGENE.
   (*a*) Volcanoes.
   (*b*) Earthquakes.
   (*c*) Slow secular movements.
   (*d*) Chemical action.
2. EPIGENE.
   (*a*) Atmospheric.
   (*b*) Aqueous.
   (*c*) Glacial.
   (*d*) Organic.

37. EXTINCT VOLCANOES IN THE MOON

HYPOGENE AGENCIES

Volcanic Action. By a volcano we usually understand a mountain, generally of conical shape, whose summit contains a crater, or opening, through which hot vapours, hot gases, volcanic bombs, ashes, and streams of molten lava are ejected during its activity. Vesuvius, Etna, Krakatoa, and Mont Pelée present familiar types of such mountains. All volcanoes, of whatever type, are simply channels of communication between the surface of the earth and the reservoir of molten rock which exists at a varying depth in the interior of the crust. In the past, however, volcanic activity has by no means been always associated with mountains of this kind. When the earth was younger, and the solid crust was considerably thinner than it is nowadays, there were vast eruptions which were due to the rending of the crust along huge fissures, often hundreds of miles in extent, from which millions of tons of molten igneous rocks welled out and submerged the surrounding country. The only recorded example of such a *fissure eruption* in modern times is that which took place in Iceland in 1783; but the study of the geological record shows that such phenomena were extremely frequent in earlier ages, and gave rise to vast masses of igneous rock.

A Simple Volcano. It is easy to see why the modern volcano is almost invariably a conical hill or mountain. If we consider what happens at a vent which has thus been opened between the molten interior and the surface of the earth, we shall see that the molten rock, welling up from within the crust and overflowing in all directions from the vent, rapidly solidifies into a roughly circular mass, of which the vent is the centre. When more molten lava is poured forth, it still wells out in the same circular form, and the cone is gradually built up round the vent, which is bored through it as a vertical pipe. The simplest type of volcano is that of a single cone thus formed around one centre of eruption. The summit is usually truncated, and presents a cup-shaped cavity, called the *crater*, into which the central pipe opens. Most existing volcanoes consist of not one, but many cones, each of which has at times been a centre of eruption. This considerably complicates the original constitution shown in the diagram [36]. A very fine instance is presented by Mount Etna, where there are at least two hundred of such cones.

Valentine

38. WAIKITE GEYSER, WHAKAREW-AREWA, NEW ZEALAND

Volcanic Products. The volcanic vents which connect the surface of the earth with the molten interior emit various kinds of material, which may be classified as gases, water-vapour, lava, and rock fragments or dust. Many of the *gases* emitted by volcanoes have a corrosive or solvent action upon the rocks with which they come in contact. Superheated steam, which is one of the gases most common among volcanic products, has a powerful disintegrating action upon the lava through which it breaks its way. The water which many volcanoes emit—generally, of course, in a highly heated condition—collects large quantities of volcanic dust, and forms a pasty conglomeration of what is known as mud-lava. The chief importance of volcanoes, however, as agents of geological change consists in the *lava* which they emit. Lava is a term generally applied to all the molten rocks which are ejected from the interior of the earth. We have seen in the preceding chapters that a large proportion of the igneous rocks which originally formed the whole of the earth's crust were once volcanic lavas. They vary considerably in chemical composition, in structure, and in texture; but a larger text-book must be consulted for details. Lastly, in addition to gases and molten lavas, solid fragments of rocks are frequently ejected from an active volcano. The larger of these are known as *volcanic bombs* or *blocks*, which are simply pieces broken off from already solidified columns of lava, and hurled out of the vent by the pressure of gas, just as a shell is fired from a cannon. A great quantity of solid matter is also ejected from volcanoes in the form of *dust* which has been produced by the disruptive effect of gases at a high temperature and under great pressure. They explode, so to speak, as the lava with which they are mingled approaches the surface. This dust is often sent floating up high into the air and is diffused by the atmospheric currents over a very large area. It has sometimes been known to travel half round the world before subsiding to the earth. The great eruption at Krakatoa, in 1883, is believed to have caused in this way the remarkable sunsets which were seen in England during the following summer.

Volcanic Action Everywhere. There is practically no part of the world, as we now know it, in which traces of volcanic action cannot be found. Once upon a time the earth seems indeed, to have been split and furrowed in all directions by the activity of the central fires which are now approaching a state of quiescence. Nowadays volcanic activity is limited to a comparatively small number of regions, and extinct volcanoes are considerably commoner than active ones. Arthur's Seat and North Berwick Law, in the Scottish Lowlands, the regions of the Auvergne in Central France, and the volcanic Eifel, beside the valley of the Rhine, offer good examples of volcanoes once active, but which have shown no signs of eruption for thousands of years. There is no essential distinction between extinct volcanoes and dormant volcanoes, as history shows that a volcano which has been extinct so long as human memory records may suddenly break out into a remarkable state of activity. This was the case *with Vesuvius just before the destruction of Pompeii. But there can be no doubt that, on the* whole, volcanic activity has steadily declined since the beginning of human history, and that a time will come when all our terrestrial volcanoes will be as inert as those of the moon [37].

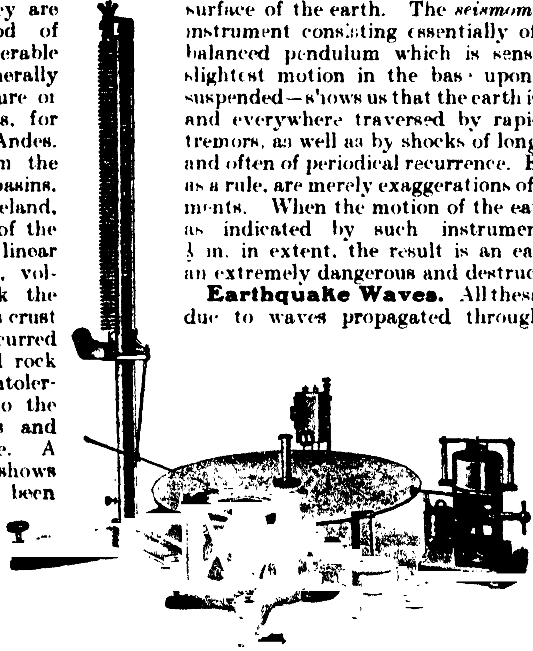
Distribution of Volcanoes. The distribution of active volcanoes, of which there are between three and four hundred now in existence, deserves study. They are found in greatest number on the shores of the Pacific Ocean, where more than half of the now active volcanoes are situated. As a rule, they are situated in the neighbourhood of the sea or of some considerable sheet of water. They are generally arranged along lines of fracture or folding in the earth's crust, as, for instance, in the chain of the Andes. Many volcanoes also arise from the submarine ridges of the ocean basins, and a few, as in Italy and Iceland, are ranged in groups in place of the prevailing distribution in a linear series. Geologically considered, volcanoes may be said to mark the places of weakness in the earth's crust where some vast fracture has occurred in the rocky mass. The liquid rock of the molten interior, under intolerable pressure, makes its way to the surface through these fractures and along the lines of least resistance. A study of the geological record shows that volcanic action has always been most abundant in certain limited areas which mark these great lines of weakness in the earth's crust. The special geological work of volcanoes and of fissure eruptions has been to bring to the surface the vast masses of igneous rock which in many cases have thus been intruded among the strata of earlier sedimentary rocks, upon which they have had a well-marked baking or metamorphic action

Geysers. In speaking of volcanic action one should mention the curious natural fountains known as *geysers* [38], so common in Iceland and in the Yellowstone Park. Those are, so to speak, water volcanoes, or springs, which rise from an extremely hot region. Their water is periodically ejected in jets or fountains by the pressure of steam formed in the lower portion of the pipe and unable to escape except by this explosive action.

Earthquakes. The study of earthquakes, known as *seismology*, has made a very considerable advance of recent years. This is largely due to the interest that Japan, as a rising nation, has been forced to take in the convulsions which are continually shaking her cities to the ground, and which compel her architects to study the conditions necessary for erecting permanent buildings, in spite of these constantly recurring and inevitable shocks. Earthquakes in our own country, as we know, are scarcely ever violent enough to endanger our buildings; at the worst a wall may be cracked, or a chimney shaken. But in the countries where earthquakes are frequent and considerable in extent they have been known to cause terrible destruction. The city of Caracas was nearly destroyed in half a minute, with 10,000 of its inhabitants. Port Royal, in 1692, and Lisbon, in 1755, were almost entirely wrecked by earthquakes.

We know now that these gigantic convulsions are merely the temporary exaggerations of tremors which are constantly passing through the surface of the earth. The *seismometer* [39]—an instrument consisting essentially of a carefully balanced pendulum which is sensitive to the slightest motion in the base upon which it is suspended—shows us that the earth is continually and everywhere traversed by rapid and weak tremors, as well as by shocks of longer duration, and often of periodical recurrence. Earthquakes, as a rule, are merely exaggerations of these movements. When the motion of the earth's surface as indicated by such instruments exceeds ⅛ in. in extent, the result is an earthquake of an extremely dangerous and destructive kind.

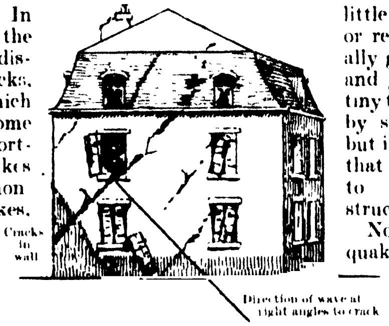
Earthquake Waves. All these tremors are due to waves propagated through the crust of the earth by causes analogous to the explosion of a mine or the fall of a huge stone. The jar which we feel throughout the house when a heavy vehicle passes along the road, or when a stout man jumps out of bed on the upper floor, is precisely similar to what we call an earthquake, though, fortunately, less in degree. These earth-waves travel at definite speeds, which can be measured with considerable accuracy and which vary according to the substance through which the waves are transmitted. They naturally travel faster through a hard and close-grained rock like granite than through a loose substance like sand. The direction in which they are travelling at any particular place can be determined by observing the direction in which walls [40] or similar objects are cracked by shock, and which are, of course, at right angles to the emerging wave. If, when an earthquake



39. SEISMOMETER

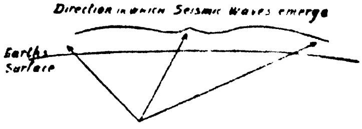
occurs, several observations of this nature have been made in different places, it is possible to make a fairly close approximation to the place at which the earthquake originated beneath the surface by prolonging lines backward from each of these stations, and calculating the point at which they would all meet within the earth [41]. It has thus been observed that earthquakes usually originate within the upper portions of the earth's crust at a depth which is seldom greater than 14 or 15 miles.

The Cause of Earthquakes. It is not difficult to see that we must look for the cause of all earthquakes, from the merest tremors insensible to man (which nevertheless leave their traces on the delicate instruments of the seismologist) to the vast cataclysms which wreck whole cities and submerge long coast-lines beneath gigantic ocean waves, in some subterranean shock or displacement. This may occur in various ways; sometimes it may be due to the sudden collapse of the roof of a subterranean cavern. In limestone districts, where the underground water is able to dissolve the substance of the rocks, and thus to leave huge caves, which every now and then become incapable of the task of supporting their roofs, small earthquakes of this nature are not uncommon. A small number of earthquakes, again, are no doubt due to volcanic explosions in the lower regions of the earth's crust. It was once supposed that earthquakes were always closely connected with volcanoes, but this proved to be an erroneous view; and, as a matter of fact, the most powerful and numerous earthquakes occur outside the limits of volcanic districts.


Cracks in wall
Earth's Surface
Direction of wave at right angles to crack

40. HOUSE SHAKEN BY EARTHQUAKE

It is now generally admitted that the recognised cause of most earthquakes is to be found in the sudden yielding of subterranean rocks which are under great strain from the superincumbent strata. It can readily be seen that at a depth of five to fifteen miles beneath the surface, where the majority of great earthquakes originate, the rocks must be in a state of extreme **strain. Every mile of the superincumbent strata is probably responsible for a pressure of 20 or 30 tons to the square inch upon those which lie beneath, and it is clearly conceivable that** every now and then the most massive rocks must yield or snap under this intolerable pressure. When they do so, a more or less violent set of waves are originated, which radiate outwards in all directions, and when they reach the surface of the earth give rise to all the destructive phenomena which we call by the name of an earthquake. There can be little doubt that these ruptures, or readjustments, are continually going on in a small way, and give birth to the constant tiny tremors which are recorded by seismological instruments; but it is comparatively seldom that they are violent enough to produce seriously destructive effects.



41. DIRECTION OF EARTHQUAKE WAVES

Not infrequently earthquakes take place on the floor of ocean basins, where they generally make themselves known by the propagation of vast ocean waves, which cause serious, and often fatal, inundations when they reach the nearest land. In 1896, nearly 30,000 people were thus drowned on the coast of Japan by an earthquake wave, which was also felt at San Francisco, nearly 5,000 miles away. Submarine telegraph cables are not infrequently broken by these submarine earthquakes, and a famous scare of invasion was raised in Australia a few years ago by the simultaneous destruction of all the cables, and the consequent isolation of that continent from the rest of the world.

Continued

Group 22

MUSIC

9

Continued from page 1069

THE PIANOFORTE

Meaning of Technique. The Instrument. The Two-fold Function of the Keys. Control of the Key Hammer. Keyboard and Pedals. Correct Position of the Hands

By M. KENNEDY-FRASER

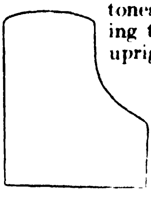
WE have already studied the Theory of Music, the nature of Scales, the laws of Tonality and the nature and function of Rhythm, etc. We have learned how music is written down, how to read its notation. We have now to learn to reproduce written music—to "make music," as the Germans say—and to do this by means of the pianoforte.

Our pianoforte education has two distinct branches. In the one we learn to conceive the effect intended by written music. We learn to hear it with the mind's ear, we learn to think it. In the other we learn to express this thought by sounds that we and our audience can hear. This latter branch we call *technique*, in the fullest sense of the term.

Technique. The learning of Technique (the power of expressing ourselves) used to depend on an aptness for imitation. Our teachers played, and we did our best to imitate them ; and, by dint of much trying, sometimes succeeded. They could teach us these matters of execution by example and suggestion only. But now both the how and the why of good piano technique have been discovered and written down for us, so that it is possible for all of us to learn from books. These books are "The Act of Touch," a scientific treatise, and "First Principles of Pianoforte Playing," a student's primer, both by Tobias Matthay. They show how it is possible to acquire (in a direct way) all the different forms of expertness included in the term Pianoforte Technique. For the term thus used in its widest sense simply means the ability to use the keys effectively and easily, and, as Mr. Matthay has said, "on our correctness in the Act of Touch, therefore, depends all success in pianoforte playing in whatever direction, agility, beauty of tone, brilliancy, power, and ability to give those inflections of tone from note to note which render music intelligible." Our entire technique depends, therefore, on our obedience to these Laws of Touch, and on our technique again depends entirely our power of expressing what we feel

To begin the study of pianoforte playing in this direct and scientific way which has thus been made possible for us, we must, before thinking of our fingers and hands, find out what the piano is, and what treatment it requires from us.

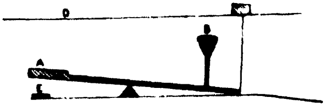
Instrumental Facts. The pianoforte is a harp-like instrument enclosed in a wooden box, the nature of which is disclosed by the "case" of a "grand" piano, which still retains this harp-like shape, although now supported table-wise on three legs. The upright or "cottage" piano, although its case is quite different in shape, is still harp-like within. The strong metal frame [1] strung with wires, from the short, thin ones giving the highest tones to the stout long ones sounding the bass, is thus no longer held upright by the player like a harp, nor are its strings plucked by his fingers. But, instead, carefully poised *hammers*, covered with thick felt, are driven against the strings to set them in vibration. These hammers are controlled by a set of cunningly devised wooden tools, overlaid with ivory or ebony at one end—the end that presents itself to the player's fingers.



1 FRAME

The instrument consists of two distinct portions : (1) the music-making portion—*i.e.*, the strings and their reinforcing sounding-board—and (2) the set of tools wherewith we may induce the sound.

Function of the Keys. Now, these "tools" have a two-fold function. They are see-saws, offering an ivory or ebony *key* to the finger at one end, and furnished with a hammer to strike the strings at the other end ; and these "keys"—note this—control the actions, not only of the hammer with which we excite tone at will, but also of the "damper" with which we stop off tone at will. Thus the keys are the tools with which we chiefly command the vibratory—*i.e.*, sound-producing powers of the instrument, and we must examine them closely. The key is a lever, of the nature of a see-saw, and its position and action are roughly shown in Fig. 2.



2. THE KEYS

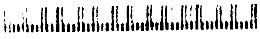
A. Ivory Key-end. B. Hammer. C Damper. D. String. E. Key-bed felt

Control of the Key Hammer. Let us press gently on the ivory end of one of the keys of the piano. It will go down under the pressure (as would a see-saw), and, the other end rising, will, if the action be swift enough, throw the hammer against the strings. The strings vibrate and produce a sound. Now release the key from the weight of the hand and arm ; the key will rise, and, as it rises, the sound will cease. What has happened ? When, by the see-saw motion of this key-end, we managed to throw the hammer at the other end against the string, did the hammer, after hitting the string, continue to press against it ? No. For, if it had done so, the string would not have been free to vibrate, and no tone would have resulted. What happened was this: the hammer, as soon as the sound was produced, fell back a little way from the string and allowed it to vibrate freely; and this the string continued to do till we suddenly released the key, and the tone as suddenly ceased.

The Damper. Why did this happen, and why must we keep the key depressed if we wish the sound to continue? Because the key, when depressed, is keeping the damper off the strings, and when the key is allowed to rise the damper is permitted to settle down again on the strings and stop their vibration. Remember, then, that when a key is moved it is the *beginning* of the sound which indicates that its hammer function has been fulfilled—all that remains, the continuance of the sound, depends on its damper function. And this is the first thing we must learn, and the last thing we may forget in using piano-keys to make music.

The Key-bed. We know something about the key with its hammer and its damper attendants, but in the key's retinue there is another small unseen, and at times ill-treated, appanage that concerns us as pianists, and must not be overlooked. This is the little piece of felt under the extreme finger-end of the key, which prevents the key from jarring against its wooden "bed" when it is pushed down. The see-saw key manages to throw the hammer against the string just before it (the key) reaches the bottom of its "bed," and if we were keen enough always to listen for the beginning of the sound and never to move the key any further than to that moment of sound-birth, these poor down-trodden key-bed cushions would be unnecessary. But careless, unskilful players, and even adepts at times, try to drive the keys too far down, and these "felts" in the bottom of the key-bed act like buffers and soften a probable, but quite uncalled-for, collision which might otherwise prove disastrous to the pianoforte mechanism. They may thus be used, but should never be abused, and, to quote Mr. Matthay, "should certainly not be squeezed 'as though they were ripe fruit from which we could extract sound-juice.'"

The Keyboard. The finger ends of the keys are not all alike. They are grouped in easily recognisable patterns in black and white. The even row of ivory—in full "grands" 52—is backed and intersected by a higher and narrower row of ebony keys (36), and these fall into alternate groups of twos and threes. The entire series (88) is called the keyboard, and the player is expected to reach and control with one or the other hand each key in this "manual" [3].



3. KEYBOARD

Damper Pedal. But in addition to the keyboard, or manual, we shall find two pedals to be worked by the feet. The right-foot pedal controls the dampers. Depressing it, we raise all the dampers simultaneously off the strings. With the damper pedal thus depressed, a tone produced by the down movement of a key will continue to sound even after the key has been allowed to rise. But this damper pedal not only prolongs the sound, even should the key rise—it affects also the *character* of the sound. For, all the strings of the instrument being by its action left free to vibrate, many of them vibrate in *sympathy* with the hammer-affected strings, adding thus to their original volume of sound, while by the non-percussive quality of their tone they affect also—and this is important—*its quality*. This right-foot pedal is often termed the "loud" pedal. It may be used while playing at one's softest, but its application will be treated further on.

The "Una Corda" Pedal. The other pedal is controlled by the left foot, and its function also is one of affecting the tone quality of the instrument. To explain its use we must again examine the harp-like arrangement of the strings. The long, thick bass strings are single—one to each hammer and key—but, as with the rising pitch the strings get shorter and thinner and consequently weaker in tone, we have two strings tuned to one pitch, and, higher up, three. The left-foot pedal when pushed down in a "grand," moves the whole keyboard with all its hammer mechanism a little to one side, so that a hammer no longer strikes all the strings allotted to it, but leaves one unstruck, and this one, sounding with a *sympathetic* vibration only, modifies the character of the tone.

That the part of the hammer which comes now in contact with the strings is less used, and consequently softer, will also slightly affect the tone. The left-foot pedal is often erroneously called the "soft" pedal. It certainly does weaken the tone-amount, but we may play at our softest without it. It is properly termed the "una corda"—*i.e.*, one-string pedal. The early piano did not have more than *two* strings, and the "verschiebung"—to use the German term for the "una corda," meaning the pushing aside—permitted the hammers to strike only *one string*. The damper and "una corda" pedals may be used together. Care should be taken when using the "una corda" pedal to *fully* depress it, provided it is properly adjusted.

How the Keys are Named. Most "uprights" are without this device, and are provided instead with a strip of felt to soften the tone, or other devices, none of which, however, takes the place of the proper "una corda."

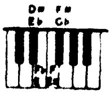
Roughly speaking, the earlier music, even up to the eighteenth century—*i.e.*, before Beethoven's time, may be and often *must* be played *without* the use of either pedal, while most of the pianoforte music of the nineteenth century—that of Chopin and Schumann, for instance—cannot be adequately performed without the use of one or both.

Now let us return to the keyboard, for it is with the keyboard that we shall have to occupy ourselves chiefly; *but* let us never forget—as pianists are only too apt to forget—that the keyboard is *not* the instrument, but merely the "set of tools" with which we may use it. We must learn, then, to be expert with these tools, so let us make their better acquaintance. Seated at the middle of the keyboard, let us pass our hands over it. It presents an uneven surface to the touch, the ebony keys lying higher than the ivories. This uneven surface is an advantage.

We must learn to read easily the music written to include the black keys, since it is easier to *play*, though more difficult at first to *read*, than music employing only or mostly the white keys.

What, tonally, does this keyboard command? A series of sounds, each half a tone apart. And its 88 keys are named with but seven letters of the alphabet—from A to G. The white keys only are named; the ebonies take their names from the ivories that lie next to them. This series of seven letters repeats itself throughout the extent of the keyboard; that from A to G was the old form of our modern minor scale, that from C to B the prototype of the modern major scale.

Eye Knowledge of the Keyboard. We must learn to recognise quickly and surely the place and letter name of each white key by its place in the *keyboard pattern*, by its relation to the groups of two and three black keys. Take D first, between *two* blacks, and find D's all over the keyboard; listen to them—all alike though different. Next find C's and E's, next-door neighbours to D's; add B's and F's, each at the extremes of the three black-key groups; and finally add A and G. We must work at this (with other studies) for days or weeks till mastered. Later, add knowledge of altered notes, notes raised or lowered half or whole tone. For such sharpened (raised) or flattened (lowered) sounds we must use the contiguous black or white keys [4]. But finding the keys by the eye, and testing their pitch, and trying to remember this by ear (as the musician must do), is, after all, only the beginning of knowledge for the pianist. *He* must learn to find and recognise the keys *blind*. This he can do only by the sense of touch and by mental muscular measurements. Again, to do this, he must learn with his fingers and hands to *rest on the keys*.



4. RAISED AND LOWERED NOTES

If we have studied carefully every word of what has been said we now know something of the instrument, and of the mechanical means provided in it for producing tone.

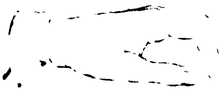
Importance of Resting. The next question is, how must we *use* the keys? How direct the arm, hand, and finger against the keys to move them? We must learn, first, to *rest* on them, that our sense of touch may tell us where they are, and that another sense—"the muscular sense"—to which we must pay great heed, may tell us how heavy they are, *how much resistance* they offer to our resting weight. In order that the fingers may really *rest* on the keys, the hand must be allowed to hang loosely—limply—from the arm. We must learn this first.

In the daily active use of the fingers (apart altogether from piano playing or study) the hand never hangs from the arms; yet in active finger piano playing it must learn to do so. This is a muscular condition which, in active use of the fingers, is quite new to us. We must study it, understand it, and be able to induce it with perfect ease, and never rest satisfied without daily testing it at the keyboard and away from it.

5. LOOSELY HANGING HAND

Position of the Hand. To learn what we mean by hanging the hand loosely on keys, let us try holding the hand *over* the keys, but not touching them, in the way indicated in 6

It is evident that *as long as we do not touch the keys* the hand (at this angle to the arm) is supporting itself; it is *not* hanging loosely from the arm; we are using its upholding muscles, the muscles that prevent the hand falling by its own weight. These must relax; they must relax so that the hand in playing may be supported on the keys by the fingers. The appearance, the mere *position* of the hand when the fingers are on the keys, will not help us in securing the loose wrist; for the wrist may be held high, medium, or low, and in any of these various positions may, or may not, be stiff. If we would make sure of the loose wrist we must see to it that the hand is really *suspended* between arm and fingers, and that being the case it will hang loosely whether the wrist-end of the fore-arm be held high or low.



6 HAND UPHELD BY ITS OWN MUSCLES

Continued

MUNICIPAL SERVICE
continued from page 1070

MUNICIPAL CLERKSHIPS

Appointments under a Typical Council. Junior Clerks and their Prospects. Draughtsmen. Clerkships. Women Typists

By ERNEST A. CARR

THE incomes of municipal clerks vary almost indefinitely, according to the duties they perform and the liberality or otherwise of their employers. At the head of the calling are such responsible positions as principal clerkships under the City Corporation, with salaries ranging between £650 and £1,000 a year. The other extremity is occupied by temporary office clerks, performing routine duties for a bare £1 a week. Between these extremes lies every imaginable gradation in value and dignity; and as there is no uniformity of system in the Service, each local authority being a law unto itself, the vast bulk of clerical employment is too incongruous to admit of precise classification. To this general want of system, however, there are many exceptions, the most notable case being that of the London County Council, whose clerical staff will be separately considered in the course of this article. It is necessary also to remember that for some officials municipal clerkships are merely stages on the road to leading or professional rank, whilst for others they are both means and end.

An Expert's Views. The courtesy of the Town-clerk of Birmingham enables us to present to our readers an admirably clear and comprehensive summary of the general prospects afforded by clerical employment in a corporation of average size. After premising that special factors may influence the progress of every clerical staff, Mr. Edward O. Smith, the Town-clerk referred to, proceeds as follows.

"Generally it is the practice for corporation clerks to start as juniors or office boys at salaries ranging from £15 to £25 a year, the necessary qualifications being, as a rule, that the lad is of good character, has had a fair education, and (in most cases) shows a good knowledge of figures. Junior appointments are sometimes filled on the recommendation of head masters of public schools who have likely pupils leaving school and desirous of getting into the Municipal Service.

"In the large departments of the Corporation, such as gas, water, electric lighting, or public works, these juniors would progress into counter, rental and exchange clerks, accountant and ledger clerks, cashiers, collectors, and district clerks, with maxima of about £150 to £180 a year. The work of these clerks is in most cases routine, but exceptional ability may be rewarded with positions as chief clerk, office superintendent, departmental accountant, etc., with salaries ranging from about £250 to £500.

"In the Treasurer's Department the same rule as to juniors may be said to exist. Here a good knowledge of figures and some bookkeeping skill are special qualifications. Appointments as cashiers and ledger clerks are usually recruited from the junior staff, and salaries range from £80 to £250 a year. In this department, also, there are higher appointments, as chief bookkeeper, chief accountant, and other posts, with salaries running up to about £500 a year.

"With regard to the Town-clerk's Department, a rather higher standard of education is required here than is the case with the other departments of the corporation. Appointments of committee clerks are usually held by the town-clerk's staff, with salaries ranging from about £200 to £300 a year. In this department are law clerks and parliamentary, registration, and election clerks, with salaries ranging from about £100 to £350 a year. In nearly all cases these appointments are filled by clerks who have gradually progressed to their position by long service and experience."

Junior Clerkships. The broad plan thus ably sketched is subject in particular instances (as its writer expressly concedes) to many modifications. A number of borough councils, for example, prefer to recruit their clerical staff by taking into their service, at more substantial salaries, youths between the ages of 17 or 18 and 21 years who have already had some special training for office life. In such cases a knowledge of shorthand and typewriting, or experience in a commercial office, is usually essential; and the remuneration, starting at some figure between £45 and £70 a year, advances annually £5 or more to a maximum of £80, £100, or £120. Promotion to higher posts, while always based upon ability and merit, is in some municipal offices dependent on the occurrence of suitable vacancies. Other authorities graduate their staff in three or four classes, providing that when an officer attains the maximum of his class his claims to promotion to the next may be considered irrespectively of office vacancies.

How to Enter. It may be useful at this stage to consider definitely what steps should be taken by a lad (or by his parents on his behalf) for whom a municipal clerkship is desired. In the first place, he should be trained to write a good clerkly hand, rapid if possible, but, at all costs, distinctly legible. Commercial arithmetic, and especially the ability to manipulate large masses of figures without a mistake, is more valuable to him than uncertain flights in higher mathematics. It follows from what has been said about the qualifications of junior clerks that a knowledge of shorthand and typewriting and the rudiments of bookkeeping are also very serviceable acquisitions.

As soon as the aspirant is moderately adept in these studies, which should be in or about his sixteenth year, the town-clerks of several suitable corporations should be approached. The larger the boroughs, of course, the better are the prospects of a vacancy. From the head official, particulars can be obtained as to the qualifications required of candidates, the age limits imposed, and the method by which vacancies are filled. If the prevalent practice is followed of maintaining a "waiting list" of suitable candidates, all that remains is to comply with whatever formalities are requisite for the insertion of the student's name, and to continue his training while awaiting notice of a vacancy. It may be, however, that the lists are already overburdened with prior claims, or that appointments are advertised—though this latter method is not generally adopted in respect of office youths and junior clerks. Recourse should then be had to other authorities; and meantime the announcements of municipal vacancies referred to in a previous article (page 451) should be scanned, and application made for such junior positions as are advertised, until, by either method, a suitable post is secured and the youth is launched on his official career.

Prizes of the Clerical Service. The general scope of municipal clerkships is clearly indicated by the expert we have quoted. Under many leading authorities, however, there are higher clerical posts occasionally accessible as heads of departments, committee secretaries, and so forth. The City Corporation, as already mentioned, offers several such prizes. The principal clerk of the public health staff, who has 30 years' brilliant service to his credit, receives £1,800 a year, his colleagues in the chamberlain's and town-clerk's office £1,000 and £950 respectively, and the chief rating clerk £850. The Metropolitan Water Board lately advanced a district secretary to a post commanding a salary of £600, and clerical appointments worth from £500 to £750 a year are similarly won from time to time in almost every busy corporation.

Necessity of Specialising. Such prizes are captured by the men who, being neither routine-bound nor content with the bare qualifications exacted by their work, have specialised as their judgment suggested. And this course is essential for the clerk who is not only ambitious, but resolved to realise his ambitions. Having chosen his work, he must sedulously fit himself for higher office than he holds. Is public health to be his forte? While still a junior he will study the statutes and bylaws, familiarise himself with the system by which they are applied, and by lending a willing hand in the preparation of minutes and reports, and in a score of other ways, will make his services valuable to the chief clerk and the medical officer. Whatever his department, indeed, he will spare no pains to become skilled in the duties attaching to it. In the Municipal Service, controlled as it is to a great extent by amateurs, there is always need of such experts, and they have good prospects of early advancements.

Draughtsmen and Tracing Clerks. These officers, although members of the general clerical staff, constitute a small and special section, unaffected by the ordinary conditions of promotion. They are employed in the departments of the surveyor, engineer, and architect, in the preparation of plans, and allied work. The earnings of tracing clerks are small—from 15s. to 30s. a week. Plan copiers earn from £130 to £180 a year, and the salaries of draughtsmen range between £80 to £100 a year for junior appointments, and £180 or £200 for seniors. A number of draughtsmen and technical assistants are employed by the London County Council's superintending architect (of Spring Gardens, S.W.), who will forward forms of application upon request. These posts are on the "unestablished" staff, and are remunerated at rates ranging from a guinea (for youths) up to 4½ guineas a week. The latter figure is rarely exceeded, or even reached, in this branch of the Municipal Service. Unless, therefore, the draughtsman has received an outdoor training which will qualify him for an assistant surveyorship, his prospects are restricted.

L.C.C. Clerkships. The foremost of local authorities, the London County Council, recruits its staff of men clerks from time to time by open competitions, resembling those of the Civil Service Commissioners, for fourth-class clerkships These examinations are open to British subjects who are over 18 and under 23 years of age on the last day for receiving applications—which is usually a week or two before the contest begins. Candidates must be free from physical defects, and are required, if successful, to undergo a medical examination before being appointed.

The competitions are held as often as a further supply of junior clerks becomes necessary. They are advertised in the chief daily newspapers for several months beforehand. Latterly, two or three examinations have taken place yearly, and a score or more candidates have been selected on the result of each. Now that the Council has become the education authority for London, it is probable that these numbers will be considerably exceeded in future.

Salaries. The subordinate staff of the L.C.C. is classified as follows:

4th class, £80, rising by £5 yearly to £100.

3rd class, £100, rising by £10 yearly to £150.

2nd class, £150, rising by £12 10s. yearly to £200.

1st class (lower section), £200, rising by £15 yearly to £245.

1st class (upper section), £245, rising by £15, and then £20, yearly to £300.

Clerks are probationers for the first year of their service, and the annual increment in every case is dependent on satisfactory conduct.

Beyond these grades are certain special appointments, such as senior assistants (£300 to £400), and principal assistants (£400 to £500), which are usually filled by the promotion of subordinate officers. Fourth-class clerks are promoted to the third-class according to merit, and afterwards according to the nature of their duties.

Pension and Provident Scheme. Unlike the majority of local bodies, the London County Council has a liberal pension and provident scheme in operation, to which each official "on the establishment" pays 2½ per cent. of his salary, being thereupon credited by the Council with rather more than double that amount.

The existing staff regulations have not been working long enough to disclose what are a fourth-class clerk's prospects of attaining an assistantship or other special promotion beyond the £300 limit. However, in view of the regular and fairly liberal increments this employment affords, and the probability that the Council's activities will continue to develop, the opening presented by such a clerkship to a youth of 18 or 19 is certainly a fair one.

Examination Notes. Details of the competitions for L.C.C. clerkships are furnished by the schedule on page 1070. There are several supplementary points, however, to which the attention of candidates should be directed.

Competitors are exempted from Part I. of the examination if they have passed it at a prior contest under the present scheme, or hold any of the following certificates:

(*a*) Matriculation at either London, Liverpool, or certain other Universities.

(*b*) Cambridge Higher Local.

(*c*) Senior Local (Oxford, Cambridge, or Durham).

(*d*) Higher School certificate, Oxford and Cambridge Joint Board.

(*e*) School leaving certificate of London University (or of the Scotch Education Office if higher grade was obtained in three subjects); senior certificate of the Irish Intermediate Education Board or Central Welsh Board; or Preliminary Arts and Science, Scottish Universities Joint Board.

Examination in General Knowledge. Among the novel features of Part II., the most striking is the compulsory examination in general knowlege. This is an ingenious test of the candidate's observation, memory, and intelligent grasp of facts. Its scope can best be judged by these specimen questions from a recent paper:

What do you know of the voyage of the "Bounty," Bushido, the Terrible Cornet of Horse, the Father-in-Law of Europe, Leander, the Magzhen the "Mayflower,," May Meetings, Pidgin English, the Scourge of God ?

Explain the phrases: *Savoir faire; Lèse majesté; Welt politik; Res judicata; Territorial waters.*

What do you know of the Round Towers of Ireland, the Towers of Silence, and Martello Towers?

Give the English names for the following places: Anvers, Bruxelles, Firenze, Génes, Genf, Köln, Londra, Marrakesh, Napoli, Venedig; and state what nations employ these designations respectively.

Classify the British Dominions beyond the sea according to the nature of their respective governments, and state as shortly as you can the points of difference between the several forms of government.

Explain precisely why a ship floats in the sea, and a balloon in the air, and why it is more easy to steer a ship than a balloon.

Definitely to prepare for such questions as these is almost beyond the art of man. Occasional readings in a concise encyclopædia might do much towards it, provided that every passage thus encountered is carefully read through. It will be found that several questions in each set relate to topical or political matters treated in the daily Press. But the student's best course is an indirect one; he must cultivate the habit of grasping clearly all that he reads, and at all costs avoid the fatal trick of "skimming."

Papers on Local Government and Shorthand. Subject 10—Outlines of English local government—is a useful study for future municipal servants; but, despite the textbooks recommended by the Council's syllabus, it is exceedingly difficult to master this topic unaided. Fortunately, however, several Civil Service colleges prepare candidates in this and all other subjects for the L.C.C. examination.

Shorthand is the subject of a special memorandum. It may be taken in Part II. as a special paper, but not for inclusion in the competitive examination. This course is adopted because "there are some positions in the Council's service," as the regulations state, "where shorthand is essential," and as that authority specially reserves the right to appoint a candidate out of the order of merit if he is qualified for a particular post, a good stenographer may win an appointment, even though he takes only a moderate place on the general list.

It may be added that the Council at times requires the services of temporary clerks, who are chosen from a list of suitable candidates kept by the Clerk.

Women Typists. The London County Council employs some 40 of these officials, who are selected by means of preliminary and competitive examinations open to women between the ages of 18 and 30. The qualifying test is a simple one, restricted to general knowledge, including stencil work, and typewriting; but candidates who take shorthand and certain educational subjects in addition may obtain first class appointments as "supervisors and shorthand-writer-typists." For Class II., the rate of pay is £55, rising by £5 annually to £65, and in the upper section to £80. Class I. officials, beginning at £80, advance by a like increment to £100, and on gaining the upper section, rise from £100 to £120. The staff being small, competitions are not frequent; each is duly advertised in the London newspapers a month or two before the actual contest. Particulars as to the examination subjects and the appointments generally, can be obtained at the Council's offices. Several other authorities employ lady typists, after a qualifying examination, at salaries ranging between 25s. and 35s. a week.

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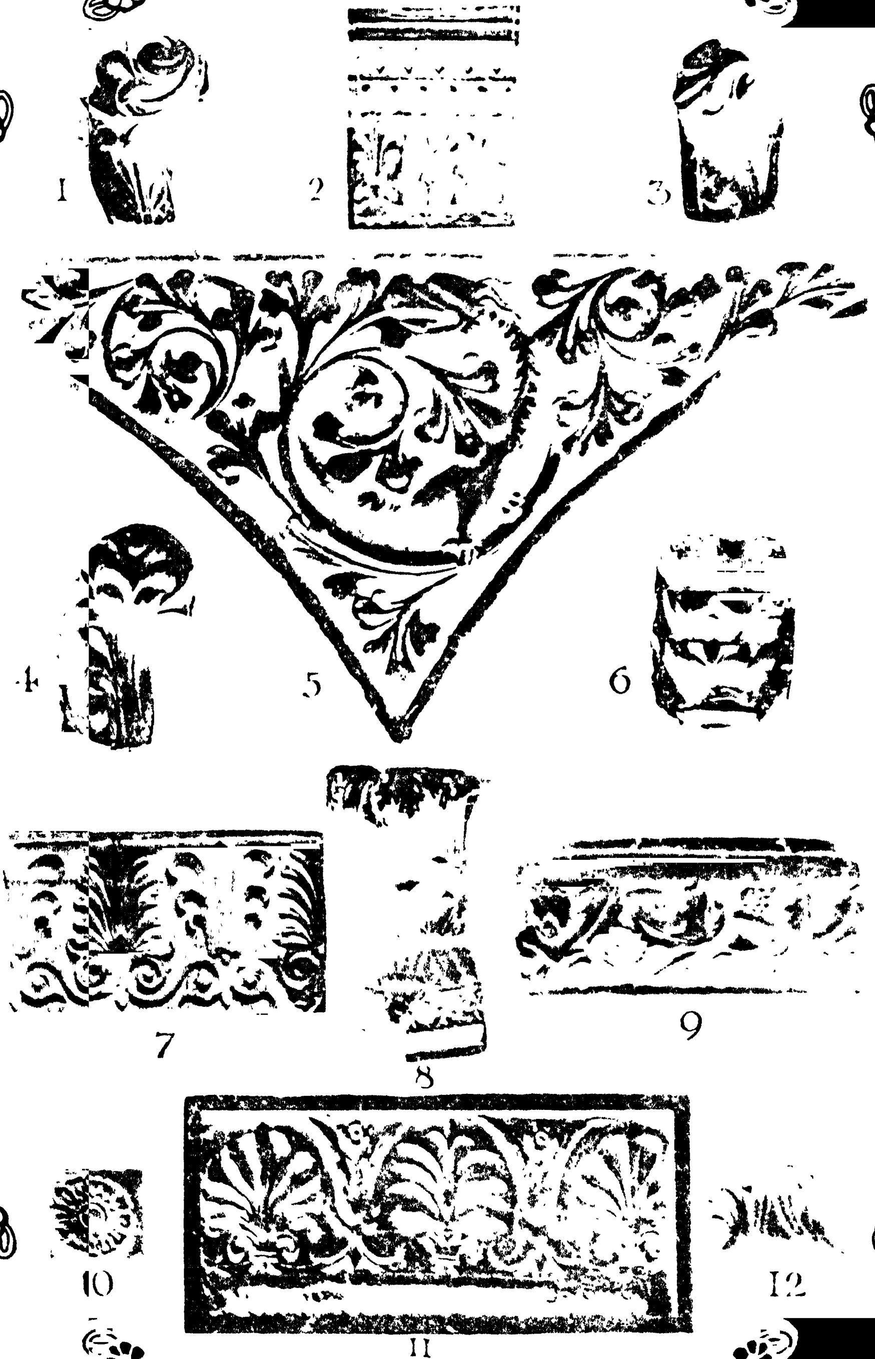


MODELS OF SCULPTURED ORNAMENTS

Greek, 2, 7, 8, 10, 11, and 12. Gothic, 1, 3, 4, 5, and 6

SCULPTURE

Flat Modelling. The Tools and Groundwork. Casting in Plaster. Modelling from Natural Forms. Protecting the Parts in Relief. Animal Study

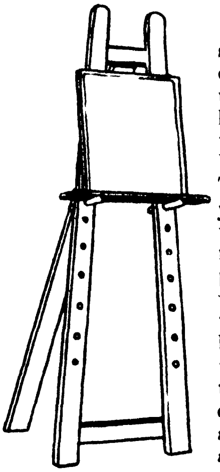
By COURTENAY POLLOCK, R.B.A., and P. G. KONODY

A THOROUGH knowledge of drawing (which is dealt with in a special section) is essential before the student can proceed with the practice of modelling.

Flat Modelling. During the first stages of the study of modelling, only a limited number of tools is needed, though, when the student has acquired some proficiency in handling clay, he may possibly find others which may suit his particular work. For relief modelling, the following are all that are needed :

An easel about 5 ft. 6 in. high, strong, and of the ordinary type, with holes and pegs, with a board 20 in. by 4½ in., to place across the pegs. Upon this you rest your working slab [13].

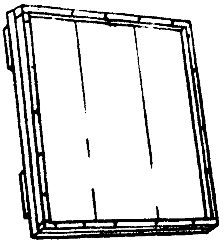
A wooden slab about 18 in. square, clamped at the back by two pieces of wood to prevent warping by the damp clay. Round the edges of the slab a beading should be fixed, so that it rises ¾ in. higher than the slab [13 and 14].



13. EASEL AND SLAB

A few wooden tools are enough to begin with. Choose those of simple form and light to hold. Those shown in 15 are recommended. They can be had at any artists' repository. The slab should be made by a carpenter or joiner, who might, in fact, make the whole easel according to instruction. It is cheaper, and may be stronger than those sold by artists' colourmen.

A piece of damp cloth, or a sponge, on which to damp one's fingers, or to keep them clean while working. Also, a piece of waterproof cloth large enough to cover the model, to prevent drying.



14 SLAB

Clay. Clay can be obtained in 2 cwt. tubs. Get the best modelling clay, which is of a light grey colour, and, when fired, changes into warm buff. See that the clay is kept damp and of a consistency that allows of easy handling by the fingers. If it gets too dry, it is tiresome to manipulate, and does not adhere easily.

With these materials before you, you may begin work by filling the wooden slab with clay. It is shaped something like a tray with raised edges. Press the clay firmly into the slab, filling it entirely and solidly—leaving no holes—and press down with the hands to a level very slightly higher than the surrounding border. Take the straight-edge shown upon the easel [13], and level down the clay by pressing the straight-edge backwards and forwards over the surface, the ends of the straight-edge resting on the edges of the slab.

When the clay surface is quite smooth, place the slab upon the easel, and begin to draw your ornament upon it with one of the straight tools, which must be held freely between the thumb and fingers, as in drawing with charcoal, not as one would hold a pen. Draw lightly, and it will be easy to correct mistakes.

Laying on the Clay. Take now some fresh clay, roll it into lumps of convenient shape and size, and lay it upon the drawing, filling in the outline and adding where it is necessary to obtain the required height of relief. Use the fingers as much as possible. Tools only serve as a help. The more you use your hands the more quickly will you become accustomed to the feel of the clay, and you will gain in precision. The fingers should not be wetted more than is necessary to keep them clean. You will learn nothing by smoothing the surface of your work. The essential point at first is to endeavour fully to understand, not only the shape of the flat outline, but—and this is more important—the shape and relative projection of every part, noting their mutual relation, and striving to imitate this, so that your own model shows exactly the same light and shade as the example you copy.

While working, you should keep your model and your own copy in the same position, without turning them to get a variety of views ; although this may be done when you have carried your work to a point at which you begin to feel satisfied that it is a good copy. At this stage, it is helpful to turn both models upside down. You will probably see at once that your copy is not as good as it appeared in its original position. Do not, however, work in any but the original position. Having once satisfied yourself where you are wrong, turn both models to their upright positions and proceed, correcting the mistakes from a diligent study of the points where you have failed. In this manner, the eye will soon become quick to notice errors in proportion and drawing.

Examples to Copy. For elementary work, one cannot do better than secure a few—say half a dozen—simple casts, such as the Greek examples, or the casts taken from Gothic stone carvings [1-12]. Avoid complicated designs ; their intricacy does not teach much. The models should be simple as regards general outline, and rather bold in relief. Avoid geometric designs; they are often quite useless, and are never interesting to copy.

Casting in Plaster. Tools must again be considered first:

An ordinary "crock" bowl, such as those used for boiling puddings. Choose a large one, of about 12 in. in diameter.

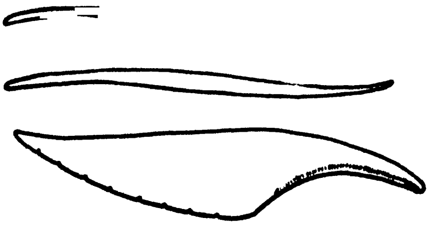
A galvanised iron spoon, such as is used for basting, to stir your plaster; a wooden mallet, small and light, and two chisels, one broad and one fine.

A small quantity of oil—sweet oil, linseed, or olive—the latter is best. Some raddle, blue powder colour, or ochre, tied in a piece of muslin, and two ordinary soft hog-hair paint brushes—one large, for washing out the inside of the mould, the other small, for applying the oil.

It is necessary to have a good water supply at hand, and also a few pieces of square iron rod, ⅜ in., cut in lengths of from 15 to 25 in. These are useful sometimes to let into the back of the cast to strengthen it, although they are not always necessary.

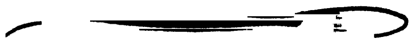
Some soft soap. A pound tin will last some considerable time.

A steel tool, such as is used by plasterers [16]. This is needed to retouch the cast where the chisel has scratched or bruised the surface during the removal of the waste mould, and can be bought at any good cutler's, one being sufficient, if well shaped, as in illustration.



15. MODELLING TOOLS

For this fine casting, none but the best Italian plaster should be used, which is obtainable at any Italian plasterer's. The "best plaster" sold by oil-stores or colourmen is quite unfit for the purpose. Buy your plaster in half bags, and keep it in a very dry place.



16. STEEL PLASTER TOOL

Making the Mould. Before the casting is proceeded with, sawdust should be spread upon the floor, to prevent the splashes of plaster from adhering to the floor boards.

Supposing the clay model to be 18 in. sq., it will be sufficient to fill only half of the bowl with clean water. Into this water dip the small muslin bag containing the dry colour, and leave it there for a few seconds, removing it when it has tinged the water with a dark colour. Take the plaster from the bag with your hand, and allow it to sift quickly through the fingers into the coloured water, until it rises to a level almost with the top of the water. At once stir it vigorously with the spoon, using the action you would employ when beating an egg, but keep the spoon below the surface, or you will throw the plaster about.

The operation must be done quickly, or the plaster will become lumpy. Do not stir whilst filling the bowl, as this may render the mixture quite useless. Place your clay model flat upon the table, and, for convenience, place strips of clay round it to form a wall about an inch high. Pour the coloured plaster over it quickly, completely covering the model. Take it up, and, holding it horizontally, shake it quickly backwards and forwards, and from side to side. Then at once pour off the plaster into the bowl, leaving a thin coating on the clay model. Air bubbles are then removed by blowing into the cavities.

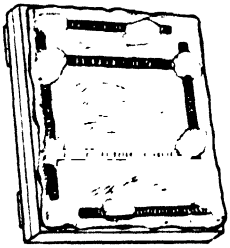
Protecting the Parts in Relief. Again pour on the contents of the bowl, and. after raising and lowering your model so that the plaster shall flow over all the surface again, pour off the superfluity very gently, and let the model rest. It is advisable now to take a little plaster from the bowl and drop small lumps upon the highest points of the relief. This will protect the high parts, and, in the chipping away of the *outer white portion* of the mould, indicate the nearness of the actual cast. Leave the model for about 8 or 10 minutes, until the plaster is quite firmly set. In the meantime, clean your bowl, and fill it again with water, without using the colour bag.

Before proceeding to thicken the mould with the white plaster, brush lightly over the coloured coating with oil, using the small brush. Very little oil should be used, or the coloured plaster of the mould may come away from the white too early, and thus ruin the cast. Now fill the bowl to within an inch with water, and sift into it the white plaster, riddling it through the fingers as before, until it appears on the surface; stir well, and pour it over the coloured coating to a thickness of about ½ in., increasing this at the edges, to strengthen it. If the clay model is in high relief, and the mould thin in places, it may be necessary to place two or three pieces of the iron rod round the edges, and a couple across the back, fixing them in position by dropping a little plaster upon them here and there [17].

Removing the Clay from the Mould. When this is set hard—which should occur in 15 minutes—turn the whole over upon its back and remove the wood slab. Should this be difficult, a little water should be run in between the board and the clay, after the removal of the small clay wall which was added before beginning the mould. Take out all the clay, using one of your wooden tools where the fingers cannot reach. Be careful not to scratch the surface of the mould. Then wash out the mould with plenty of water, using the large brush. Every particle of clay must be carefully removed. Now take some soft soap, and, having rinsed the mould thoroughly, lather it well with the brush until the surface has a good shine. Plentiful use of soap lather will sometimes do away with the use of oil, but it is advisable to pass a little oil over the projecting portions of the mould, to facilitate the removal of the coloured portion in the process of chipping it away.

The operation of filling the mould and draining the plaster off again, is now repeated several times, until the fresh plaster is about 1 in. thick all over. It should be given time to set, as the cast might crack if chipped too soon.

Chipping. Now turn the whole over and lay it upon some soft material, say a sack. With the broader chisel, chip off the iron rods and the thick covering of white plaster. The high points of coloured plaster will appear first, and thus indicate the thickness of the plaster to be removed, and give roughly the outline of the design. Remove all the white portion of the mould; then, very delicately tapping with the small chisel, gently remove all the coloured coating. The amount of retouching required will depend on the degree of care exercised. The very small pieces of the mould are removed with the small end of the steel tool shown in **16**, which is also used in filling in with fresh plaster scratches and abrasions made by the chisel.



17. BACK OF MOULD

Modelling from Natural Forms. When the student has acquired fair skill in handling the clay, he should seek suitable forms in Nature for study. The diligent study of foliage, flowers, and tree-growth—in fact, of practically everything in Nature that the student can intelligently copy—will help him more than a lifetime spent in making copies of other people's work, however good they may be. It will give *knowledge*, which is the most potent factor in the education of an artist.

Small sprigs will do for the beginning. It is not at all necessary to select a sprig on which the leaves seem to grow in a pleasant arrangement. Take any sprig that has not been damaged, no matter how ill-balanced it may seem. Nature does not make mistakes, and you are not designing now, but learning the growth of Nature. The springtime affords ample opportunity for studying development in Nature. The gradual development of the leaf-buds, for instance, is irresistibly interesting. Take a sycamore bud and look at it carefully, noting the angle at which it grows upon the stem, and observing how the leaves are bursting through their cover in the most wonderful forms.

The student cannot do better than stick some of these buds on his clay slab and make a number of studies of them, till his memory has retained the forms from the bud to the full leaf. The same minute study should be carried into the consideration of the stems and trunks of trees. In some cases, where the detail is too fine for clay, pencil studies will be found helpful, but one can, as a rule, correctly suggest the detail, if one understands what one is copying, and is satisfied as to its shape and appearance. The beautiful flower known as "Love in a Mist" is a good instance. It is quite impossible to copy every bit of the fine, fibrous mass which surrounds the flower, but careful observation and a little thought will enable the student to represent it, by suggestion, on his clay. However, for the purpose of learning how to *model* plant form, it is best to select plants of simple, bold form, and to depend more upon pencil studies for learning the plant itself.

Animal Study. The study of animal forms should follow that of plant form. Several books have been published containing photographs of animal life, but we cannot recommend the practice of working from such plates, because the photographs do not sufficiently explain themselves, and their study is neither interesting nor very instructive. If very good and clear, and of fairly large size, they may be useful at times in affording opportunities for studying such details as are not affected by movement; but it is infinitely preferable to study from the living subject, and not at all necessary to make the studies in the clay direct. In fact, the student will learn more quickly if he depends upon pencil studies when working from live animals. Such studies allow him to record movements, and consequent change of surface forms, which are impossible to make note of in clay.

The constant movement of the animal may be troublesome. When you have seized the chance offered by the animal's lying down, and have half completed the drawing, the model will change the pose of its head, or rise and seek a more comfortable position. This need not worry you. If the unfinished drawing has been done with care and thought, it is useful, and has taught something.

Many students consider a study incomplete if it is fragmentary. This is an error. To learn what an animal is, and how it moves, it is not at all necessary to make laborious drawings of the complete creature; much may be learnt by quick and limited "notes."

Continued

Group 12
MECHANICAL ENGINEERING
9
APPLIED MECHANICS
continued from page 1083

APPLICATIONS OF HYDROSTATICS

The Hydraulic Cylinder and Ram. Hydraulic Jacks of Various Types. The Punching Bear and Wheel Press. Hydraulic Lifts and Cranes

By JOSEPH G. HORNER

Hydraulic Rams. Pursuing the applications of hydrostatics into varied mechanisms, we find that the most important is the hydraulic cylinder and ram. In this appliance a solid ram or plunger fits within a cylinder into which water under pressure is admitted, thereby causing movement. The cylinder, or else the ram, is set in motion thereby. Generally it is the ram that moves, as in the hydraulic platform or station lift, and in baling presses, or flanging presses, types of a hundred other machines. But sometimes the cylinder is made free to move over the fixed ram, the alternatives being matters for convenience. Obviously, too, the positions of the mechanism are of no importance. Though in most cases set with the axis vertically, they are often horizontally, and in some cases inclined. Also the lift may be direct, the table platform, or platen, being attached to the head of the ram. Or chains may be brought round pulleys at the head of the ram, and, with suitable anchorages, used to impart motions that are not in a direct line with the movements of the ram. These occur in jigger hoists, and in many kinds of hydraulic cranes. Pressure is also often transmitted by jointed or walking pipes instead of rigid ones, to avoid having to reconnect, as in hydraulic riveting plants.

It should now be readily seen that, given the foregoing elements, capable of producing strong pressure and transmitting it by a liquid which is practically incompressible, enormous possibilities in application are opened up. The following are a few examples which are selected from a much wider practice, and each of which occurs in machines the details of which are modified in many ways in the hands of different manufacturers.

The Hydraulic Jack. This is a simple machine for gaining enormous power, but with its accompaniment of very slow movement, resembling in this respect the differential pulley blocks. Both are invaluable when heavy loads have to be lifted by human energy alone. The jacks will lift locomotives, ships, bridges, by the operation of a hand lever, and in modified forms they will push loads slowly. They are emergency tools out of doors, where cranes are not available. Their general construction is shown in **148**, which represents a Tangye lifting-jack that combines two functions in one—that of lifting on the head A, and also on the foot B, the latter being an invaluable addition when there is little space between the object to be lifted and the ground. The construction of the jack is as follows.

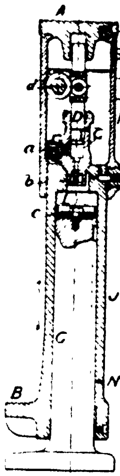
C is the body of the force-pump, and D its ram, actuated by the lever E, drawing the water from the cistern F, by the pressure on which between the ram G and the casing J the latter is forced upwards. In the force-pump CD we recognise the same type of pump that was illustrated in the previous article [page 1083]. The difference in the area of its ram D and that of the ram G of the jack represents the theoretical gain in pressure.

Operation of the Jack. When in operation, the cylinder J should first be down to the bottom of the ram, as shown by the drawing. The cistern F is then filled with liquid, either by removing the cover A or by taking out the charging screw H and filling through its hole. Clean water must be used, or rain water, or condensed steam with ¼ oz. of soda added. In cold weather glycerine is added to the water to prevent freezing—one part of glycerine to three of water. The lowering screw, or stop-valve K, is then unscrewed, and the lever E, pivoted at *d*, worked a few times, by which means water is forced through the pump into the space L, and any air present passes through the valve K into the cistern F. A little more water is added through H to take the place of the air driven out. The air-screw M is left slightly opened all the time to allow freedom of escape to the air. The cylinder J rises on the ram G until the water comes out of the blowhole N, though it is not well to lift to the extreme limit, as the leather packing (*c*) is liable to become damaged.

To lower the jack, the screw K is slackened, which leaves a free passage of the liquid from L to F. If the height to which a load has to be lifted exceeds that of a single "run-out" of the jack, then the jack is raised on blocking, and another lift taken.

There are a good many practical points about the working of these jacks, but only one can be referred to here—the care of the leather packings (*c*). Nothing yet has been substituted successfully for leather, so that the old saying "nothing like leather" is in this connection absolutely true. A peculiarity to be noted is that the leather is cupped in such a way that the harder the pressure the more tightly is the leather pressed out against the walls of the cylinder. Sometimes even a leather which will be leaking when a ram is doing no work will cease leaking as soon as a load is put on. The troubles to which leathers are liable are mainly due to their drying and shrinking. Next to these the presence of grit is most harmful. When leathers have to be cleaned they are taken out and soaked in water or oil.

With regard to lifting a load on the claw B, it is obvious that the full load which can be taken on the head A cannot be put on the claw. It is, therefore, not judicious to carry more than



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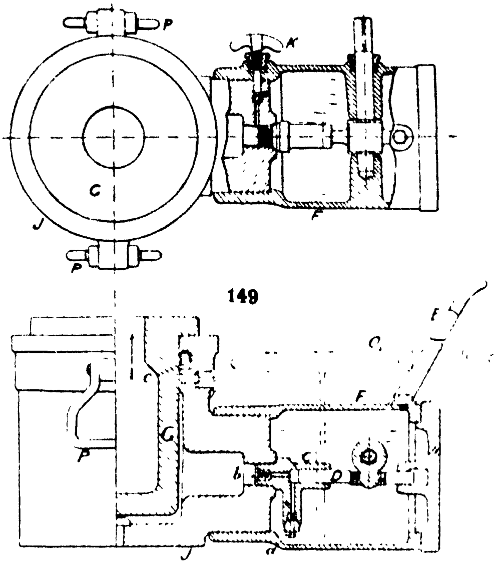

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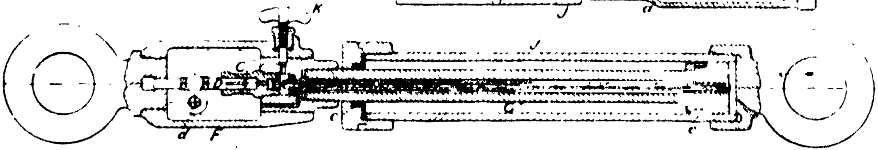

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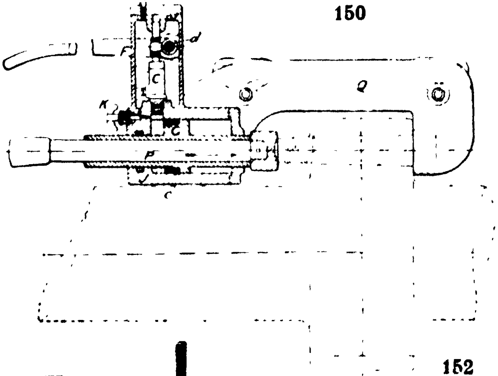

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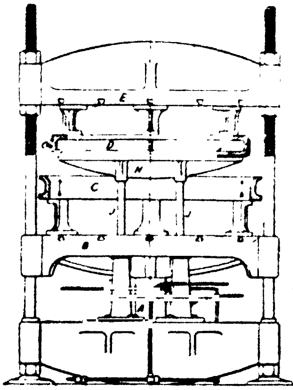

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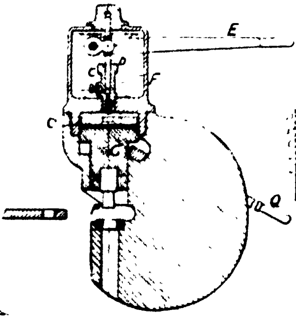

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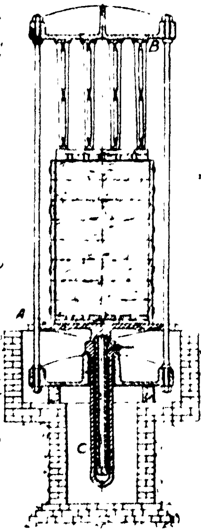

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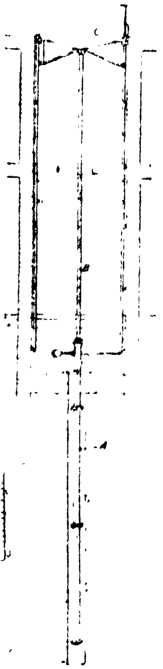


155

HYDRAULIC PRESSURE MACHINES

25 per cent. of the jack-load on the claw if the lifting be a high one. For a short lift nearly the maximum load may be carried with safety.

Modified Jacks. Around this simple mechanism, which is but a modified form of the essential Bramah press, engineers have built many designs, a few of which we shall now notice. Some of the reference letters are retained in the subsequent figures for the purpose of ready identification of similar parts.

Given the jack itself, one of the first improvements effected with a view to increase its range is to impart a horizontal motion bodily to it—the *traversing jack*, a movement effected by a screw. An object after being lifted can thus be moved along bodily within a limited distance.

Ship Jacks. Jacks are utilised for lifting ships, hence termed ship jacks [**149**], though, of course, suitable also for bridges and other heavy works. Here we recognise the force-pump, but set in a horizontal direction, and operating a vertical ram. But while the jack in **148** is made for loads up to about 50 tons, the ship jack is made as high in power as 400 tons, which explains the enormous disproportion in the diameter of the rams D and G in **149**, the drawing being made to scale. Note also the great thickness of the metal in the cylinder J which encloses the ram, and receives the pressure tending to rupture it. The only other differences that need be noted are the form of the packing leather, and the safety-valve in **149**. The leather (c) is of the U section, that being more suitable than the cup form in **148** for withstanding enormous pressures. The weighted safety-valve lever O, though often omitted, is desirable because of the severity of the pressure, which, if much exceeded, might rupture the cylinder or the pump. The power of this small jack is thus equal to the lifting of four of the largest locomotives with their tenders.

Pulling Jacks. In these examples the power is applied to the exercise of thrust or push, but it is equally applicable to a pull. A special form, therefore, is the pulling type [**150**]. There are confined spaces where even the snug pulley-blocks cannot be used to pull a load, as in shaft tunnels, and sometimes in the engine-rooms of steamers, and then the pulling jack, operated by a pressure pump, is a boon to the men who have to execute hurried repairs.

This jack has the same cistern, force-pump, and stop-valve, but a tube (G) takes the place of the ram, and the water pumped from the cistern passes through the bore of this tube to the underside of the piston. The latter forms an enlargement at the end of the tube, and has a U leather packing (c). The eyes fitted at the ends are in union, one with the cistern and thence with the tube, the other with the cylinder for connecting to the work, and to any suitable point of attachment. In operation, the tube is drawn out as far as is required, and the act of pumping pulls it in, drawing the work along with it. The jack is used indifferently in a vertical or horizontal position. Machines of this kind are made with powers as high as a 25-ton pull, with a maximum run-out of 36 in.

The Punching Bear. Nor is it only in pushing and pulling that the coercion of pressure-water is in evidence. The same essential mechanism—that of the small ram of a pump and the large-power ram—are used for punching holes through steel, and for shearing the edges of steel sheets. Fig. **151** shows one of the first variety, which is made by Messrs. Tangye, of Birmingham, a most useful machine, termed the punching bear. Its utilities lie in the formation of holes in girders and other plated work in localities which do not admit of the utilisation of the fixed power operated machines. A man or two men can handle this machine, yet it is powerful enough to drive rivet-holes through iron plates ¾ or 1 in. thick.

The top lever E actuates the force-pump, and sends pressure-water into the chamber above the ram G, pushing the latter down. The punch P being fitted into a hole in the latter partakes of its movement. The function of the lower lever Q is to raise the ram and punch, previous to which the stop-valve must be opened to allow of the escape of the water back into the cistern.

Around this design many larger punching machines are built for special work. They include machines for punching tram rails, girders, channels, and copper sheets. Some are portable, being mounted on wheels for movement to work in progress, on railways, and in streets. Some have so little resemblance to others that a superficial observer would hardly see the relationship, but they all embody the same principle—that of the Bramah press. Some, too, are used for closing rivets. Also, by substituting shear blades for the punch and its bolster, we have the hydraulic shearing machines, a large group.

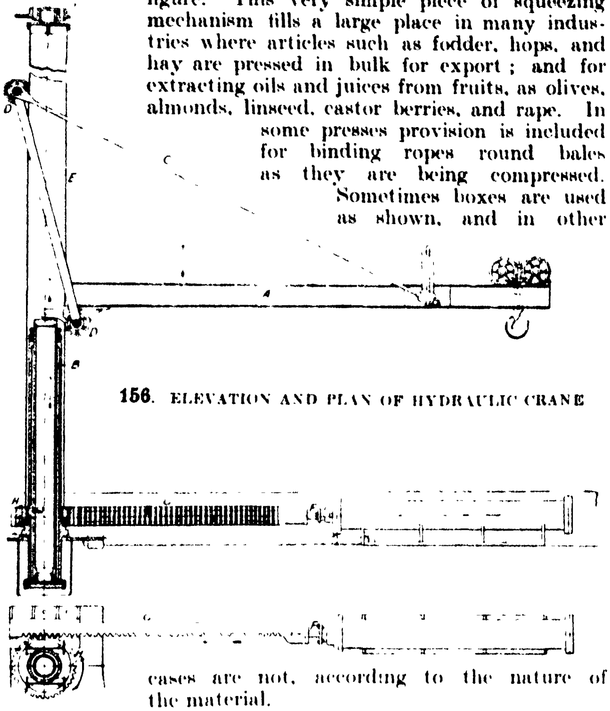
The Wheel Press. This is a machine for pulling railway wheels on their axles, and taking them off by the simple exercise of water-pressure. The wheels on their axle are slung between heads, which afford the necessary resistance to the water pressure. They are capable of exercising total pressures ranging from 80 to 200 tons. Many of these are worked from an accumulator.

Bolt Forcer. The same principle is adopted in the bolt forcer [**152**], a small machine which pushes bolts home, and rusty ones out of their holes. They are capable of exerting pressures of from 20 to 75 tons on a refractory bolt. The ram here (G) is hollow, to receive a steel drift (P) which is forced along by the ram against the tail of the bolt to be pushed out. The resistance is taken by the arms or claws Q, two in number, so flanking the bolt on each side. A propeller shaft with a bolt about to be forced out of the flange is indicated in dotted outlines. The arms (Q) have handles for lifting and transportation. Figs. **149**, **150**, and **152** illustrate examples from the practice of Messrs. Youngs, of Birmingham.

Another machine forces the big propellers of ships off their shafts by the persuasive power of a little water judiciously applied.

Yet another group identical in principle of operation include the bending and straightening machines. These may often be seen in the streets where tram-lines are being laid down. Pressure either to bend or straighten is applied between the end of the ram and a pair of claws, or hooks, opposed thereto, and to right and left, the rail being gripped between so that the pressure takes place at three points. Pressures of 40, 50, or 60 tons are thus obtainable.

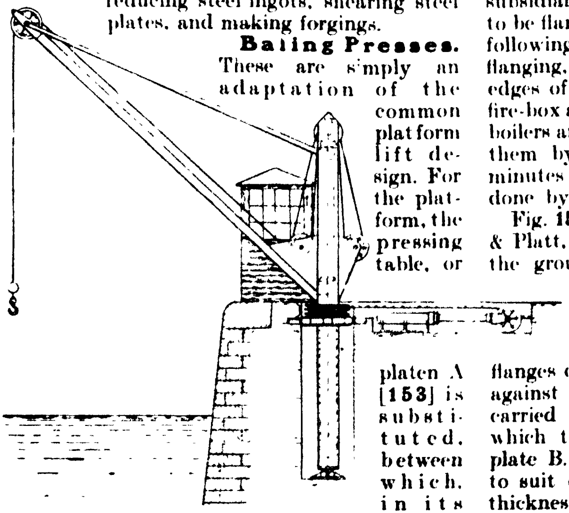
In the shops there are larger machines used for straightening steel beams, precisely the same in essential mechanism, but differing in outline, being fixed on massive bed-plates. When steel girders, joists, bars, and other sectional forms have to be either bent or straightened, this is not done by the brutal method of hammering, but by squeezing. The machine may be described as a hydraulic jack (the ram) so mounted as to push the girder or beam in opposition to two points of resistance. Being under control, the pressure can be arrested when the beam is either straightened or bent to the curvature required



156. ELEVATION AND PLAN OF HYDRAULIC CRANE

Presses Using Accumulators. The members of this group are as numerous as those we have already considered, and they are generally much more massive in form. The most familiar are those for lifts for passengers and goods, for pressing or baling, flanging, squeezing and reducing steel ingots, shearing steel plates, and making forgings.

Baling Presses. These are simply an adaptation of the common platform lift design. For the platform, the pressing table, or platen A [153] is substituted, between which, in its upward movement and the head B of the machine, fixed above, the loose material is pressed, often with a force of from two to three tons on every square inch. Hay is pressed thus into a bulk one-sixth that of the original truss. The motive power is still the force-pump and accumulator actuating the ram C in the figure. This very simple piece of squeezing mechanism fills a large place in many industries where articles such as fodder, hops, and hay are pressed in bulk for export ; and for extracting oils and juices from fruits, as olives, almonds, linseed, castor berries, and rape. In some presses provision is included for binding ropes round bales as they are being compressed. Sometimes boxes are used as shown, and in other cases are not, according to the nature of the material.



157. HYDRAULIC CRANE

Flanging Presses. These are a special variant on the baling press and kindred types. They contain more mechanism, in the form of subsidiary side-rams, that push the boiler plate to be flanged up against one die, which is fixed, following which the main ram pushes the flanging, or movable die up, so bending over the edges of the plate against the fixed ram. The fire-box and tube-plates for locomotive and other boilers are turned round thus, instead of flanging them by hand, the process occupying a few minutes against hours required when they are done by hand hammers.

Fig. 154 illustrates a flanging press by Fielding & Platt, Ltd. The cylinder and ram are below the ground, as in the baling press, but only the top of the ram is shown in the figure, at A. This lifts the movable plate B, which carries the lower flanging die C on stools, which die flanges or turns over the edges of the plate G against the edges of the upper die D. D is carried by stools against the fixed plate E, which thus resists the pressure of the lower plate B. E is, however, adjustable in height to suit different pieces of work and different thicknesses of dies. Before the actual flanging of the plate G takes place, the plain plate is brought up and held against the upper die D by the plate H, which has a vertical movement independent of that of B through four small hydraulic rams J. The object of this provision, distinct from the squeezing, is to permit of making precise adjustments of the plate before flanging it. Hundreds of these machines are in use, doing work with a silent squeeze better, as well as more quickly, than hand work was ever capable of doing.

Forging Presses. These form an immense group, comprising machines more or less specialised. The largest forging press in the world is the 14,000-ton press of the Bethlehem Steel Works. There are some immense presses in Sheffield for forging down ingots for armour plates. Essentially they comprise the ram and cylinder. They have entirely displaced steam hammers for the most massive work. It would be impossible to forge the big propeller shafts and the guns and armour plates by steam hammers with sound results, to say nothing of the concussion of hammers, which does not exist with presses.

In forging presses are included large groups which deal with comparatively light work, which they bend and mould in all conceivable shapes. At the Swindon G. W. R. Works and elsewhere there are numbers of these presses in a great shop in silent operation making buffers, horn blocks, and the numerous forgings required for carriages and waggons.

Lifts. In the direct-acting lift [**155**] the hydraulic cylinder A is sunk in the basement. By the admission of pressure-water from the accumulator, the ram B is lifted. As it carries the platform C on its upper end, the platform partakes of the lift movement, and is carried up to a distance corresponding precisely with the amount of vertical travel of the lift. The descent is accomplished by gravity, by letting out the water, the rate of which is under control. The capabilities of this simple mechanism are almost without limit. Two extremely powerful installations of this kind are the canal lifts at Les Fontinettes, and on the Canal du Centre, Belgium. In the latter a trough of water, weighing 1,100 tons, and containing a barge, is lifted to a height of 50 ft. in 2½ minutes. This load is sustained by one ram 6 ft. 6¾ in. diameter, and the pressure is 470 lb. to the square inch. On the Neuffossé Canal, at Les Fontinettes, similar lifts, but weighing 700 tons, are lifted 43 ft.

Hydraulic Cranes. As these were the first mechanisms to which water pressure was applied (by Armstrong, at Newcastle), so they are still used to an immense extent for light as well as heavy loads. Details vary widely from the plain types shown in **156**, **157**, to the vast coal-tips which lift a 20-ton waggon of coal, tip it, and return the waggon to the rails in a minute.

The crane shown in **156** is of the direct-acting type—that is, the jib A with its load is lifted by the upward movement of the ram B. The jib is steadied by the rods C and rollers D above and below against the post E. The rotation of the jib is accomplished by another ram (F), set horizontally, and moving a rack (G), turning a wheel (H) that encircles the post E. More often a chain is used for turning, as indicated in the skeleton drawing **157**. In this example the lifting of the load is done with a fixed jib. The ram is shown at the top of its stroke, and its movement draws the rope or chain round the pulleys shown, so lengthening or shortening the lift at the hook.

Other Applications of Hydrostatic Pressure. The foregoing is a small but representative selection of the utilities of power-water. The following is a short summary only of other ways in which hydrostatic pressure is employed in engineering structures.

It is applied in many turning operations, for, as we have seen, the cylinders can be arranged in any positions, and connected by chains or racks and pinions to the parts to be moved. Hence we have it working the steering gear of the largest ships, for which hand power would be utterly incompetent. Large swing-bridges are operated similarly. There are many of these in existence for road and railway traffic. One of the latter, over the River Ouse, at Goole, weighs 670 tons, and is actuated by engines having three cylinders arranged radially, and worked by water at a pressure of 700 lb. per sq. in. One over the River Tyne weighs over 1,200 tons. The huge bascules of the Tower Bridge are raised and lowered by hydraulic engines, besides which the hoists for taking foot passengers up to and down from the high-level footways are actuated hydraulically.

Dock gates are opened and closed by hydraulic rams, arranged horizontally, and connected with chains to the gates. In other cases the chains are wound on to, or unwound from, drums by hydraulic engines. Docks having openings as wide as 100 ft. have their gates opened and closed thus by pressure-water.

Big guns are also manipulated hydraulically, and the recoil also taken thus.

Mention has been made of the hydraulic punch, the shearing and flanging machines, but these are only faintly representative of the vast utilities of the pressure-water in our factories and on public works. Numbers of distinct and separate types of machine tools, some fixed, others portable, are in use in nearly every big engineers' works and on great public structures. A modern boiler is never built without the aid of these tools; seldom, if ever, is a bridge erected or a steel ship constructed without their having a big share in the work. It would be difficult to say which is the more useful—the heavy, fixed machines, or the lighter, portable kinds. The latter enable many operations to be performed that a few years ago were deemed impossible except by hand work—operations done in awkward situations and where the work is too massive to be taken to any machine. Holes are punched and drilled, rivets closed, and steel cut, control being exercised by the movements of simple valves operated by handles. But the power behind it all is the pressure-pump and the accumulator, with its storage.

Continued

COOKERY

Kitchen Requisites. Kitchen Ranges and Gas Stoves. A Marketing Guide. Care of Kitchen Utensils. Substitutes for Scales

Continued from Page 1004

A PROPERLY-EQUIPPED kitchen is a matter of no little importance. Any apparatus which is time, labour, or money saving should be eagerly sought after by an intelligent mistress who wishes to facilitate the cook's work. Nowadays, most of the necessary utensils are well within the means of the average housewife, if she does not allow herself to be tempted by the showier and more expensive varieties of the same thing. On the other hand, very cheap goods are not true economy. On all sides one is met by fascinating, artistically coloured enamel-ware, often labelled "bargains." In many cases the enamel cracks the first time they are used—notably the frying-pans. Once cracked, it will burn easily, and not infrequently fragments get into the food, which is, of course, a source of great danger. There is also a risk of arsenical poisoning with inferior enamel.

Useless Utensils. Very cheap tinware has much the same objection—spouts drop off, and handles come out if used for any more powerful heat than a spirit lamp; though good blocked tin is a light and very useful metal for fish-kettles, light tea-kettles, etc.—providing rust is carefully guarded against.

Copper pans are most durable. They are handsome in appearance and excellent conductors of heat; but they are expensive, and the greatest care must be taken to keep them scrupulously clean, and to note that the tinned lining does not get out of repair, or fatal cases of verdigris poisoning may occur.

Perhaps the seamless sanitary steel pans are as serviceable as any. They are practically everlasting, easily re-tinned, and less expensive than copper. There should, of course, be a few tinned, and enamel-lined iron ones for harder wear.

The steamers with several compartments over one boiler are most useful and economical, and it is a pity that the handy little Dutch oven is not more patronised—it is such a capital invention for all grills, toasts, and for roasting small birds.

The "Bain-marie." Another invaluable utensil but little met with in ordinary kitchens is the *bain-marie*. It is a shallow pan, about 8 in. or so deep, which stands on the stove, and is kept half full of boiling water. Into it are put all saucepans the contents of which need keeping hot without becoming dry or boiling. If a complete *bain-marie*, with pans to fit, cannot be afforded, the pan itself could be procured or made in some strong metal, and the ordinary household pans fitted in. Casseroles, a "hot-pot," a few fireproof-ware dishes, a frying basket, hair and wire sieves, a forcing bag with a few pipes, one or two French cooks' knives, vegetable cutters, and a mincing machine are amongst some of the very desirable apparatus in a modern kitchen, and will be found to aid greatly in giving a finish and a professional touch to many dishes which otherwise would appear quite uninteresting.

Care of Kitchen Utensils. Nothing is so disheartening to a careful housewife as to see the kitchen appliances in which she took such pride, and perhaps had some little difficulty in purchasing out of her housekeeping allowance, going to rack and ruin during the reign of some careless or ignorant cook. Many mistresses are, however, so uncertain as to the way a saucepan should be cleaned, and what is necessary for its cleaning, that they cannot judge if proper methods are used.

SUPPLIES FOR THE SCULLERY.

Soda
Dry Soap
Scouring Soap
Emery Paper
Silver Sand
Whiting
Pieces of old woollen material to rub with
Saucepan Brush
Scrubbing Brush
Dish Cloths
Bath Brick

There is no need for scullery work to be made the untidy, unpleasant business it so often is. Dirty utensils should be quickly washed instead of being laid aside till the next morning, or till the grease is cold, and mixtures set and hard.

Pieces should be scraped into one plate, and knives stood upright in a jug of hot soda-and-water so that the handles are not discoloured and loosened by being put into boiling water.

Saucepans. All dirty pans should at once be filled with water and a little soda, so that instead of becoming dry the scraps sticking to them soften and are twice as easily cleaned.

If saucepans are burnt, they should be filled with cold water, some soda added, and the pan left to boil on the side of the stove for about an hour, when it may be easily cleaned.

Any saucepan, no matter of what it is made, should be scoured inside and out. The absurd idea that the hand should be used to rub the pans is happily dying out; a saucepan brush and a piece of stout, rough stuff, first soaped and dipped in silver sand, and then well rubbed over the saucepan is all that is needed—with the addition of "elbow grease."

Enamelled pans should not be washed with soda, which causes the enamel to discolour and crack. Sand also is too sharp, it scratches the glaze. The cloth should be dipped in some fine ash or crushed egg-shells to remove stains.

Never tolerate a soot-coated pan, it wastes fuel and time whilst the heat is penetrating.

Keep all pans bottom upwards in a dry place, with their lids neatly beside them or hung in graduated sizes on the wall. Pans not turned over, and left with their lids on, are not infrequently dirty if an inspection is made.

Rust. It should be remembered that rust and dirt in utensils mean ruin to the delicate flavour of foods cooked in them.

Copper pans or moulds well repay labour expended in cleaning them. After scouring inside and out, brighten them by putting some silver sand in a saucer, add to it a little salt, and moisten it well with vinegar. Dip a piece of cloth in this mixture and rub the copper part *only* with it; a used half of a lemon can well take the place of the cloth. Then rinse it well in cold, soapy water, and dry it. On no account let this acid mixture touch the tinned parts, as it stains them badly.

It is recommended by several good authorities that to keep copper bright for several weeks the outside should be dipped in boiling ale and placed near a fire to dry, but *not* wiped.

Frying-pans, and omelet pans specially, should not be washed, as it is apt to cause the food to stick. All pieces adhering should be scraped off, and the pan rubbed over with pieces of soft paper till clean. Give a brisk rub with a dry cloth and put the pan away in a dry place.

To Polish Tins. If tins are at all greasy or burnt, they must be first washed in hot soda-water and scoured by dipping a piece of well-soaped cloth in silver sand, rubbing them all over with it and then rinsing them.

When dry they should be polished by mixing a little powdered whiting to a paste with cold water, rubbing it well on, and polishing it with a soft, dry cloth or leather. Be sure and brush it well out of all corners, avoid putting on too much, and let it dry a little before polishing.

Wooden Goods. In scrubbing wooden goods do not use soda, as it makes the wood a dirty yellowish colour. Wring out the flannel in hot water, and soap the scrubbing brush. Wash over the wood, then scrub it well, following the lines—that is, the grain—of the wood with the brush. Rinse off the soap thoroughly and dry well. To dip the brush in sand is a very good plan, and whitens the wood; but great care is needed to rinse it well off again.

A Scouring Paste. For very dirty tins and wood long neglected, and, indeed, for any cleaning of that kind, the following preparation is invaluable:

1 pound of soft soap
1 pound of silver sand
1 quart of boiling water
1 pound of powdered whiting
1 tablespoonful of salt

Put all in a saucepan. Stir and boil well for about fifteen minutes. It may be kept for a long time. For wood, use it in place of soap and sand.

Cooking Stoves. It is unfortunate for the head of domestic affairs when the stove is inferior or faulty; there are so many excellent makes on the market that it is a condition of affairs which ought not to be tolerated. Those in most general use are open ranges, closed ranges, and gas stoves. The most useful combination is a range which, by a simple contrivance, can be converted into either an open or closed stove—and a gas stove, as well, for boiling the kettles for early cups of tea, hot weather cooking, etc.

An Open Range is to be recommended for ventilation of the kitchen, comfort and a cheerful warmth, airing linen, roasting meat.

A Closed Range is superior for cleanliness, saving of wear and tear of the pans, etc., simplicity of regulating the heat, economy of fuel (if the dampers are understood), personal comfort when cooking.

Management of Stoves. To manage any stove successfully, it should be remembered that:

1. Perfect cleanliness is essential: dirty, greasy ovens with a charred deposit from various bakings will ruin the flavour of any foods.

2. A flue is a passage like a small chimney leading—one from each of the two ovens and the central fire space—into the large chimney. Through the flues is drawn *up* the hot air, smoke, and flame, to be replaced by a *down* current of cold air, thereby causing the necessary *draught.*

3. Dampers are metal plates, like horizontal shutters, jutting out across the flues behind the back of the range. These dampers can be pushed in to cut off the draught by closing the flue, or give free access to the air by leaving it open. Any intermediate position between "pushed in" or "pulled out" can, of course, be adopted.

4. The stronger the draught, the quicker and fiercer will be the heat of the stove.

5. Soot is a non-conductor of heat. It wraps up the ovens and boiler in a soft woolly covering, through which it takes a long time for even a little heat to penetrate. It also chokes up the flues, preventing draught.

6. The stove should not "roar," as it is called, or become red hot. It indicates that the fire is "drawing" too quickly—that is, there is too great a draught—with the result that the coal is consumed in an extravagant manner, and the redhot surface dries the air, making it very unhealthy. Roaring can be quickly checked by putting in one or more dampers, closing the door in front of the fire, and pushing in the ashpan under the fire.

How to Manage the Dampers. When first lighting the fire, pull out all dampers; usually there are three.

If much hot water is required, push in the dampers over the oven and leave the centre one out.

For baking, pull out the damper over the oven that is required, and push in the centre one and that over the oven which is not needed. If both ovens are wanted, only push in the middle damper.

If the ovens are getting too hot, push the damper half way or right in.

If the fire is to be merely kept in a little—say, between luncheon and tea-time—push all the dampers nearly, but not quite, in.

Remember that, unless one damper is left, at any rate, a little out, there will be no outlet for the smoke, and it will pour out of the top of the stove.

How to Save the Coal.

1. Have all the cinders sifted to mix with the coal.

2. Select a hard coal for the range, or mix it with coke.

3. Burn all possible kitchen refuse when you can afford to slacken down the fire.

4. Regulate the dampers carefully.

5. Keep the flues and spaces over the ovens free from soot, so that they heat quickly.

6. Keep the fire well made up, stoking it frequently, but only putting on a little coal at a time.

When to Clean the Stove. The chimney should be swept at least every six months.

The flues must be brushed thoroughly at least once a week, or oftener, if a very soft coal is used or a great amount of cooking done.

Brush well over the tops of both ovens every morning.

Wash the inside of the ovens well—the shelves, sides, and door—at least once a week, with hot soda-water. Use a stiff brush, and, if necessary, scrape the shelves with an old knife.

Gas Stoves. These have nowadays been brought to a very high pitch of perfection, and are an enormous convenience in districts where gas is laid on, and the rates are not so high that their use is almost prohibited to all but the wealthy.

For cooking in hot weather, and for small flats, they are a great boon, because the gas can be turned out or lowered, as desired, and much unnecessary heat saved.

Unfortunately, householders complain of the careless waste of gas caused by the burners being left full on when not needed, or the stove being used when, perhaps, there is already a large coal fire burning in the kitchen.

Besides this trouble, there is not infrequently an objectionable odour in houses where the cooking is done by gas, so much so, that on entering the front door, it is easily noticeable that the stove is lit. The reason for this is either:

1. The dirty condition of the top of the stove under the boiling rings, and the interior of the oven.

2. Too great a pressure of gas being turned on for the size of the stove.

3. The stove being "lit back," as people express it—that is, the draught causing it to light in the air chamber of the burner. This may be known by the peculiar noise made, and the flame will be of a yellow, instead of a blue colour. It also causes a most unpleasant smell, and soon the burners become choked with soot, and very little heat is given. When this occurs, the gas must be turned out and lit again, and even several times, if necessary, till it lights properly. To prevent it, the gas should be turned on for a second or two before the match is applied.

If possible, choose a stove lined throughout with enamel, and the rests for the shelves made to pull out. This kind is so easy to clean, and the bright lining reflects the heat and aids the cooking operations.

The stove should also be provided with a good griller or toaster, the heat from the burner, by a simple contrivance, being thrown downwards on to the bread, or whatever it may be.

To Clean Gas Stoves. Remove all parts possible—bars, shelves, etc. Wash the top or any greasy part thoroughly with hot soda water.

Blacklead and polish all the black portions. Clean the bars with emery paper, and any brass fittings with bathbrick dust and a leather, or soft cloth. Should there be any tiles on the stove, wash them with hot water, soda, and a piece of house flannel.

Carefully note that the holes of the burners are not choked with grease from pans boiling over. This point is very frequently forgotten, with the result that a very small jet of flame is obtained.

Substitutes for Weights and Scales. Though most convenient, weights and scales are not an essential item in the kitchen, and in very many households they are conspicuous by their absence. But it is unwise to trust merely to guessing the quantities; and the following table will be helpful, giving, as it does, equivalents for the usual weights:

1 heaped tablespoonful of flour .. .	1 ounce
1 tablespoonful of moist sugar	1 ounce
Half a tablespoonful of syrup, jam, etc. =	1 ounce
1 tablespoonful or two dessertspoonfuls of liquid .. .. =	1 ounce
4 teaspoonfuls of liquid . .. .. =	1 ounce
1 breakfast-cupful =	half a pint or half a pound
1 teacupful = ¼ of a pint .. .. .. =	¼ pound
6 lumps of sugar .. .. =	1 ounce
A piece of suet, butter, lard, or clarified fat, the size of a small hen's egg =	1 ounce
Weight of an average-sized egg	2 ounces
Half a candied lemon or orange .. .. =	1 ounce

Testing the Oven. It is well to test the heat of the oven before putting in the meat, tart, or whatever it is. To do this, place a piece of white paper on the shelf, and leave it for five minutes. If it has turned

Light yellow, the oven is "slow"
Dark yellow „ „ "moderate"
Dark brown „ „ "quick"
Black „ „ "too hot"

A MARKETING GUIDE

When at all possible, every housekeeper should do her own marketing; she will then be able to study the prices of the various things, and avoid those articles which, owing to various reasons—such as the demand for them, or the weather—are high in price on that particular day; while, at the same time, she may sometimes be able to give her family delicacies which, as a rule, she would consider beyond her means.

However slender the family purse is, it is bad policy to purchase inferior goods; stale fruit, withered vegetables, and stale fish are highly injurious.

Meat

When choosing meat, it is well to remember that a joint containing much fat or bone is not economical. Also, that young meat, such as veal and lamb, contains less nutriment than the flesh of mature animals, such as mutton.

Beef. Good beef should be of a fine, even grain, veined with fat, which should be firm and of a creamy dull white. The lean should be a purplish red. Scotch beef is considered the best.

Mutton. Good mutton should have small bones; the lean should be of a dark red, and the fat hard and white. If the flesh is flabby and damp, it is inferior.

Veal. Veal should have a fine grain, with the fat very white. If it is very young meat, it contains little nourishment, and it is considered by many to be indigestible.

Pork. Pork should never be purchased in hot weather, but is excellent during the winter months. The lean should be of a delicate, pinkish white, with the grain fine and close, and the bones small.

Bacon. Bacon with the lean of a very deep red is usually very hard and salty. The fat should be of a pinkish white, and the lean free from cracks.

Fish

When choosing fish, see that the eyes are bright and the gills a clear bright red; the body should feel stiff and the flesh firm. Very large fish of their kind should be avoided—they are usually old and stringy. It is absolutely essential that shellfish be perfectly fresh, otherwise it is most unwholesome; if in good condition, it should feel heavy in comparison to its size—a light lobster is always watery. If a lobster, crab, prawn, or shrimp is fresh, the tail is drawn tightly against the body; pull back the tail, and it will immediately spring again to its place. An oyster-shell will be firmly closed if it is fresh; if it gapes a little, the oyster is losing its freshness.

Poultry

When choosing poultry, see that the eyes are clear. The bird should be plump, without being over fat, the legs smooth and supple, and the feet large for the size of the bird. The skin should be free from hair, these denoting age. Hen birds are considered more tender than cocks, and those having yellow legs are generally preferred for boiling.

Choose ducks and geese with yellow legs; those with deep orange coloured legs are usually ancient birds.

Select rabbits with soft brown fur and large joints—these are the signs of youth; old ones have greyish fur and rather blunt claws.

Game

For roasting, choose young birds; but for salmis, stews, and soups, old ones will do excellently. As a rule, hen birds are considered more tender and juicy than cock birds. If young, the quills will be soft, and in the cock bird the spurs short and smooth. The under part of the beak will snap across if it is bent back, and the legs will be smooth and supple.

Venison is not considered worth eating unless it has plenty of clear, bright-looking fat.

The legs of wild duck, teal, and widgeon should be soft and pliable.

Young hares should have smooth, sharp claws, thin ears which can be easily torn, and large knee joints. They should be chosen for roasting purposes, though old ones do very well for jugging.

Vegetables

On no account purchase stale vegetables; they are most unwholesome. Cabbages which are limp, battered about, and turning yellow should be avoided, also withered lettuces and cress. It is poor economy to purchase cheapened goods when half of them is useless; it is far better to get half the quantity for the same money. This is particularly so in the case of green peas. It is more economical to purchase half a peck at one shilling a peck than one peck at sixpence. In the latter case, the pods would probably be yellow and withered, and the peas dry and hard, consequently taking a long time and much fuel to soften them; while in the former, they are fresh, green, and soon cooked.

If at all possible, buy potatoes in large quantities, and store them in a dry, dark place for winter. A rough-skinned potato is generally floury, but there are some exceptions to this rule. Small potatoes are not economical, even if low in price, as so much of them is wasted in peeling.

Fruit

Like vegetables, fruit must be fresh and in good condition, otherwise it is best avoided. Wellington apples are the best variety for baking in tarts or mincemeat.

Dry Stores

If buying flour for ordinary use, "households" or "seconds" is the best, while "Vienna," or pastry "whites" is best for cakes, puff pastry, etc.

As coffee, oatmeal, and all spices deteriorate with keeping, they are best purchased as required, in small quantities.

Rice, sago, sugar, etc., may be bought in large quantities, provided they are kept in covered jars away from the dust.

Household soap should be purchased in large quantities, as it dries with keeping, and so is much more economical.

Continued

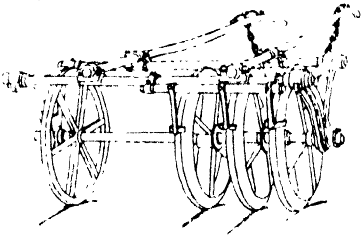
Continued from page 1200

CULTIVATION OF LAND FOR CEREALS

Ploughing, Harrowing and Sowing for Wheat, Barley, Oats, and Root Crops. Mangels and Weeds. Time for Drilling Seeds. Catch Crops

By Professor JAMES LONG

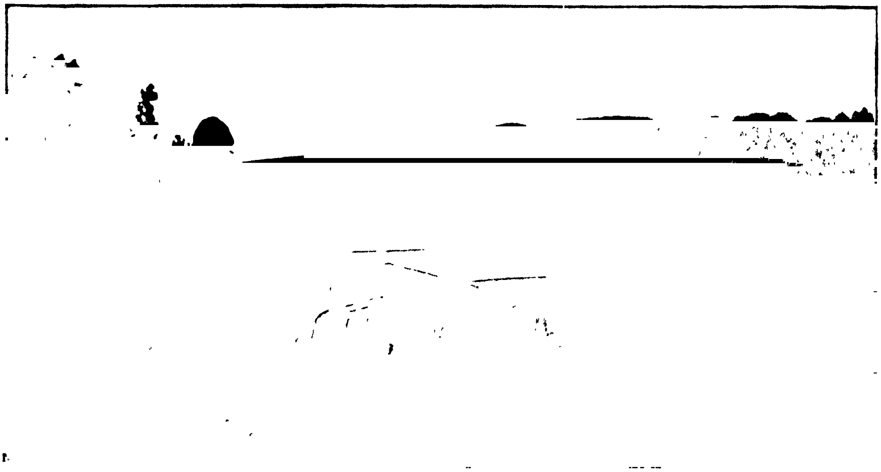
WHEAT is usually sown on land which has been dunged and which belongs to the heavier class of soil. The land is ploughed early, harrowed, and the seed drilled. In some of the lighter land districts where wheat is grown the soil is ploughed rather shallow, furrows are made with a ring-presser to provide a firm bed, and the seed is broadcasted and covered with the harrows. Heavy land often needs weathering after ploughing before harrowing is possible, by which we mean that the sticky, clay-like soil turned over by the plough must be brought to such a condition by the aid of wind, rain, sun, or frost, that it will break to pieces when the harrows are drawn over it. As wheat needs a firm bed, care must be taken not to plough too deeply, nor to make the soil too loose. Wheat being an autumn-sown plant, it is often essential to make water-furrows to prevent rain-water collecting and thus destroying it.



RING-PRESSER

Barley. The object of the barley grower is not only to obtain a large yield, but fine samples for malting purposes. In spite of foreign competition and the employment of barley-malt substitutes, a good sample will still realise a respectable price; but a sample which is unfit for malting falls to a low figure, owing to the much smaller value of this cereal for feeding purposes. Quality depends upon the soil, the season—especially during ripening and harvesting—and the method of cultivation. In the most suitable districts the barley crop is a profitable one, but in unsuitable districts, and largely on heavy soils, it is much more difficult to obtain quality. Barley is very commonly taken after a root crop fed off by sheep, for the reason that it thrives upon the enriched shallow surface soil, upon which the flock has been folded to eat off swedes, turnips, sainfoin, rape, kale, and other plants provided for them. It is, however, a recognised principle that a field intended for barley should never be too rich, or a sample may be spoiled. When, therefore, its condition is higher than is desirable, oats or wheat may be taken before the barley. Barley is also taken after a potato crop, this tuber, being a gross feeder, seldom leaving too large a residue of plant food, unless it has been heavily manured.

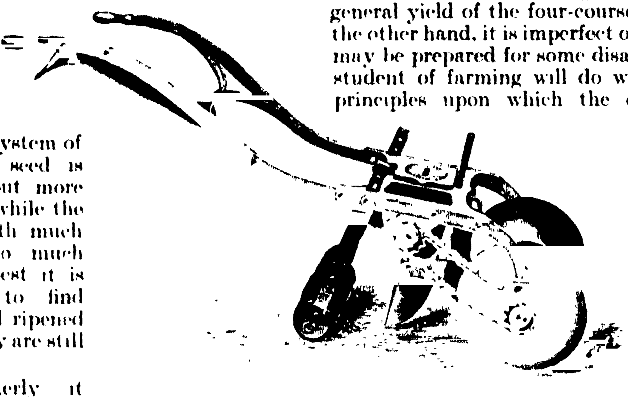
It is most essential that barley should be sown in a very fine seed-bed, and this is another reason why it should follow a root crop, for, in preparing for roots by several cultivations, the tilth is made both deep and mellow. In such a case the land needs but a shallow ploughing, the object being to provide fineness above and firmness below, and yet the soil must be dry. The seed-bed must be prepared in dry weather by using the most appropriate tools, as the



PLOUGHING: BREAKING UP A NEW FIELD

curved tined or drag harrow, the medium spiked harrow, and the roller. Above all, poaching must be avoided, especially where the soil runs together and becomes impossible of cultivation when trodden upon by either men or horses. In order to obtain evenness of growth the seed should be drilled, that it may be deposited at an equal depth ; covering may be completed with light harrows, that the soil above the seed may remain in a kind and mellow condition.

Oats. Oats are sown in two seasons, although the winter oat, which is drilled in early autumn, is common to but few districts. The grain of the winter variety is preferred by many owners of horses, especially of hunters, while the straw is much superior in strength and form to that of the spring oat, which is usually sown between the end of January and early April. When the weather is open, the earlier the sowing the better. The seed-bed may be deeper than for barley, but it is not necessary to produce so fine a tilth, the oat being a vigorous growing plant, and thriving on almost all classes of soil which are sufficiently provided with food, and which are clean and dry. The system of broadcasting the seed is quite common, but more seed is required, while the plants appear with much less regularity, so much so that at harvest it is not uncommon to find the majority well ripened while the minority are still almost green



MANGEL DRILL

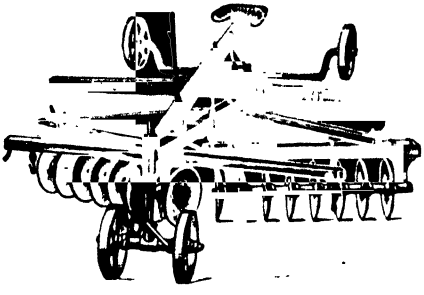
Peas. Formerly it was the more general practice to sow the earliest peas in autumn, but in these days farmers prefer early spring. The pea demands a tolerably fine seed-bed, for which reason the land should be ploughed as soon as possible after the previous crop has been removed. The first drilling may be in January, if the weather permits, the blue flowered varieties being selected, further sowing following from time to time until the middle of March. As the season advances, the later varieties are sown. Land intended for peas should not be touched during wet weather, for, where poaching follows the treading of horses and men, success is impossible. Care must be taken to guard against the depredation of birds, especially of the wood-pigeon, which quickly finds and steals the seed.

Beans. Beans are commonly taken after wheat on strong land, and are sown early in the year, what are known as winter beans being first selected, the spring varieties following in due course. The bean stands moderately severe weather without harm on dry or well-drained land. It requires a fairly deep seed-bed, which need not be exceptionally fine in tilth. The land should be ploughed in autumn, that its condition may become sufficiently mellow, and a suitable day being selected, it may be harrowed down and drilled at once. When drilling is impossible, the method of dibbling may be resorted to, for it occasionally happens that sowing would otherwise be much delayed owing to the impossibility of taking the horses on to the land without damage. In dibbling, holes are made with a hand-tool, and the seed deposited in rows at equal distances apart. Before the bean plant appears, harrows may be drawn over the field with the object of killing weeds which may have begun to grow ; when the rows are sufficiently defined, the horse-hoe may be employed with the same object. Land intended for beans is occasionally manured with dung, covered in by the plough in autumn.

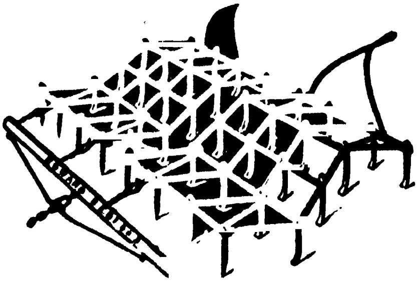
Roots. By the preparation of the soil for the root crops, by which we mean mangels, rabi, swedes, and turnips, although potatoes may be appropriately included, the whole rotation is affected. If the work is good, it tells upon the general yield of the four-course rotation ; if, on the other hand, it is imperfect or bad, the farmer may be prepared for some disappointment. The student of farming will do well to master the principles upon which the cultivation of the soil is founded in relation to fallow land.

It may here be remarked that there are two classes of fallow, the one applied to land which carries fallow crops, among which roots are included ; the other, known as bare fallow, chiefly applied to very heavy land. The object of bare fallowing was formerly intended to provide the soil with a rest, and to give it time to accumulate fertility before it was asked to produce another crop. In these days bare fallowing is chiefly resorted to for the purpose of cleaning land, ploughing being conducted from time to time during the hot weather of summer, when, by the aid of the sun, weed-life is destroyed. The more this subject is studied by the student the more clearly it will be shown, however, that, unless in exceptional cases, a bare fallow is a waste. If it is regarded as impossible to grow a saleable crop with profit, it is preferable to sow for a green crop, which may be ploughed in as green manure, and in this way to prepare a field for a profitable succession.

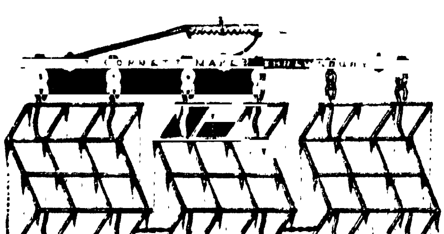
Elements of a Successful Root Crop. A successful root crop largely depends upon early autumn ploughing. The land intended to carry mangels should first be tackled, if possible immediately after harvest. If time permits, it may be skimmed 2 to 3 in. deep with the broad share, which not only accomplishes quick work, but destroys growing weeds, and induces weed seed to sprout ready for subsequent burying with the plough. In this work the sun may possibly be an available helper. Subsequent work with the harrows will largely remove such obnoxious weeds as twitch or couch-grass before the plough starts its work. In some cases, especially on light soils, the steam cultivator is introduced, and the land is twice stirred, one cultivation crossing the other. Such practice makes it easier for the horses when ploughing begins. On the heavier soils, which have been similarly prepared and harrowed, the soil being dry, the land may be ploughed to a depth of 6 to 7 in. If this is permissible, as it should be for the mangel, which flourishes best on deep, strong, rich loams, the soil may be subsequently ploughed with the ridging plough, and left rough through the winter. By this means the clods will be pulverised by frost, the soil forming the ridges will remain fairly dry, while the rain-water will find its way into the furrows between.



THE DISC HARROW



DRAG HARROW



A SET OF HARROWS

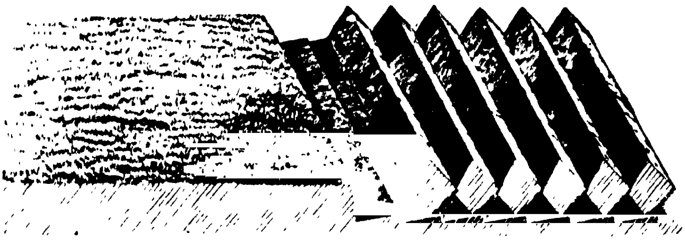
Autumn Ploughing. So much depending upon autumn cultivation for roots, the necessity of early sowing and harvesting will be recognised. But it must not be supposed that early autumn ploughing is essential for roots alone. The land may be prepared for wheat and beans, oats and barley, where it is intended that the seed for these crops should be sown early. Land should not be touched with plough, harrow or roller while it is wet, although there are some of the lighter soils upon which work may proceed very quickly after heavy rain, and here experience, which begets judgment, will stand the student in good stead. Roots not only demand a fine and deep tilth, for which reason a fine surface tilth should not be buried, but they demand sufficient moisture near the surface to encourage the early germination of the seed. How important this point is will be noticed if the thick, hard husk in which the seed of the mangel is enveloped is examined.

Drilling of Mangels and Turnips. Both mangels and turnips are drilled upon the ridge on the heavier soils ; the whole of the soil forming the ridge should, therefore, be fine. Before ridging for the drill with the double-breasted plough—this being the final operation with this tool—root land is usually spring ploughed once or twice, according to its condition. When this is sufficiently perfect, the ridges are drawn, usually 27 in. apart, and the furrows between manured with rotten dung, and where mineral fertilisers are employed, with these also. The plough then passes through the middle of each ridge, splitting it in halves, covering the manure, and at the same time forming fresh ridges. These are subsequently pressed with a light roller —for it is essential to prevent the soil "running" or sticking together by extreme pressure—and on the flat surface thus produced the seed is drilled. Swedes and turnips germinate better when drilled quickly after this operation and while the land is still moist. Swedes are sown between the middle of May and the beginning of July, depending upon the district and climate, the dates of sowing being earlier in the south than in the north. Turnips are sown during June and the first half of July, while stubble turnips, frequently broadcasted, are sown between the middle of July and the last week in August.

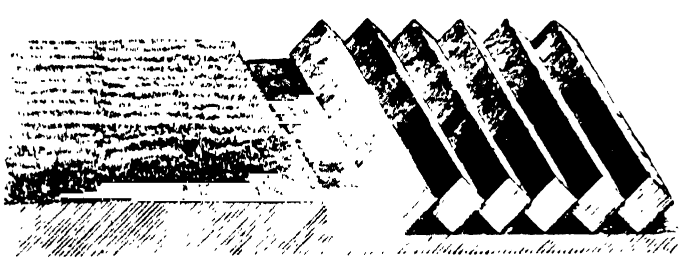
The student will do well to notice the difference in the rapidity of the germination of turnip seed on a coarse or dry tilth and on a fine, moist, fresh tilth, which has been lightly rolled. The mangel, owing to its preference for stronger soil, is generally sown on the ridge, with manure beneath ; while the swede, although the same system of manuring is sometimes followed, is more commonly manured with phosphatic manures alone.

It is important that in all cases the ridges upon which roots are grown should not be less than 27 in. apart in order that the horse-hoe may be more easily and advantageously employed in keeping spaces between each row of plants perfectly clean. The mangel plants, which, with successful germination, produce almost unbroken rows, are subsequently singled with the hand-hoe, each bulb being left from 9 to 15 in. from its neighbours. The wider the bulbs are apart the larger they grow, but while medium bulbs involve more labour in lifting at harvest, they are richer as a food. Mangels are frequently grown on the flat on the lighter soils, for the reason that they better obtain the necessary supply of moisture.

Mangels and Weeds. Owing, however, to the fact that weeds grow more quickly than the mangel plant, it is good practice to mix with the mangel seed in the drill a small quantity of turnip seed, which appears earlier than the mangel plant; then the rows may be seen sufficiently early to introduce the horse hoe before the weeds have taken absolute possession of the soil. The mangel is sown between the end of March and the middle of May, and the variety selected will depend upon the experience of the grower. Some find the Globe or Tankard superior to the Long Red, which is more difficult to lift owing to the fact that a larger proportion of the root grows within the soil. For this reason it frequently breaks off in pulling, involving extra labour or loss. The object of the grower, however, should be not only to obtain weight per acre, but weight of food per acre, and this he will secure by selecting varieties which are known to contain a high proportion of feeding matter and to grow them closer together in the rows than usual.



CRESTED FURROW SLICE



RECTANGULAR FURROW SLICE

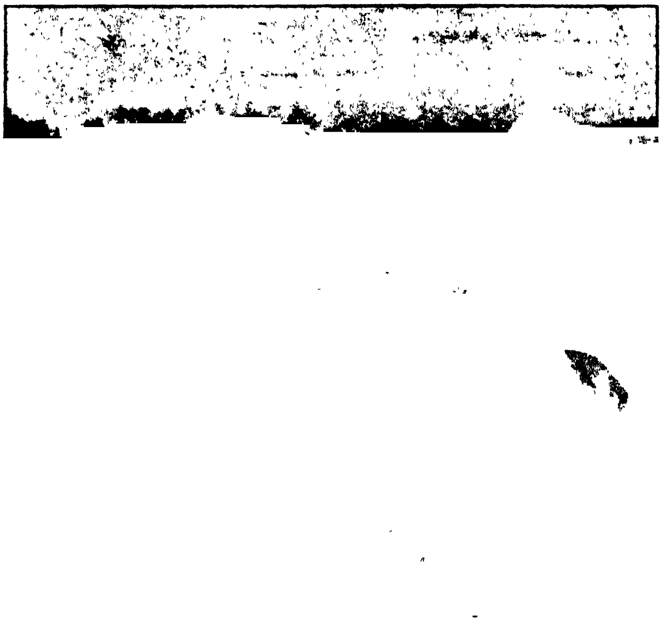
FURROW SLICE BROKEN UP

METHODS OF PLOUGHING

Where blanks occur in a mangel field they may be filled up by planting cabbage or kohl-rabi, unless swede seed, having been sown with the mangel seed, plants of this root are in possession. Whether the mangel land has been supplied with dung, after ploughing in autumn, or under the seed in spring, it may be advantageously dressed with nitrate of soda during its early growth. This fertiliser may be supplied at the rate of ½ to ¾ cwt. per acre when the young plants have been a fortnight above ground, while a second and similar dressing may be provided when they are half grown.

Clovers and Seeds. Clover is usually sown alone, a common practice with the broad red and crimson varieties, to which reference has been made; but under varied conditions, depending upon the purpose for which the crop is required, and upon some soils, the character of which must always be consulted, mixtures are sometimes preferred. These mixtures may consist of the clovers proper—broad red, cow-grass, alsike, and white, or one or more of these varieties added to Italian rye grass, or, where the plant is to remain on the ground for two years or more, yet temporarily, with the addition of cocksfoot, catstail, and occasionally lucerne and smooth and rough-stalked meadow-grass, as shown in the chapter on grasses. Temporary mixtures are usually known as "seeds," or "leys," and the seeds are sown with a corn crop.

Clover is usually drilled, especially where it is grown with wheat, but the seed should not be deposited more than half an inch in depth. Where, as should be the case, the soil covers the seed after the drill, it may be found sufficient to roll it, otherwise, as where it is broadcasted with the seed-barrow, it should be covered with light harrows, and subsequently rolled. In some instances it is sufficient to cover with a bush-harrow, skilfully made by fixing a number of strong blackthorn boughs to a hurdle or an implement equally convenient. Again, some farmers find it satisfactory to cover the seed with a horse-rake, but in all cases rolling, the weight of the roller depending upon the class and condition of the soil, should follow. The farmer, too, must judge whether he should sow his mixture of seeds at one or two operations. The seed-barrow is of great width, and takes a long sweep, but, careful as the workman may be, he frequently misses the line of seeding, with the result that when the plant appears many places are recognised which were never seeded at all. This is prevented by dividing the seed into two portions, and sowing the second portion across the first. In using the seed-barrow it may constantly happen, too, unless care is exercised, that the small, heavy clover seeds remain at the bottom of the box, and are not equally scattered with the grass seeds by the brushes within.


CARTING MANGELS

Sutton

Time for Drilling Seed. Occasionally seed is drilled with spring corn, but on soils where the tilth is fine and deep, this is liable to bury the fine clover and grass seeds, which prefer a shallow, firm bed. The more general practice is to wait until the oats or barley have appeared, and are sufficiently strong to permit of the drill being used, or for the operation as conducted with the seed-barrow. Both sainfoin and lucerne, which may be regarded as seeds, are similarly drilled with, or among growing corn, but in no case is the crop obtained in the same year, although, where the growth is precocious, there may be sufficient green food cut when the corn is harvested to improve the value of the straw. The cropping of clover, sainfoin, and lucerne assists in renewing the fertility of the soil, but it is inadvisable to allow either plant to remain down long enough to become so foul that the land is in part impoverished by weeds, or rendered difficult to clean and cultivate for a succeeding crop.

In some cases, where the soil is foul, beans may replace clover in the rotation, for the reason that the land, as already explained, can be horse-hoed between the rows forming the crop. Land intended for seeds should always be well supplied with lime, which may sometimes save a plant from the ravages of the eel-worm, the chief enemy of broad clover. With this object half a ton of ground lime, preferably produced from chalk, may be sown per acre.

Forage, or Catch Crops. A "catch" crop is a crop which is taken between two regular or rotation crops, as crimson clover sown upon wheat stubble, and removed sufficiently early in spring for turnips to be sown. These crops include crimson clover, vetches or tares, rye, winter barley and oats, all of which should be sown early in the autumn, that they may be cut green and removed early in spring. Before sowing it is advisable that the land should be well cleaned by surface-harrowing for the destruction of growing weeds, and to incite the germination of weed seeds. The land, except for trifolium (crimson clover), which is sown upon the harrowed stubble, should be shallow ploughed, and the seed drilled and harrowed in while the surface is dry and kind. Where, however, time permits, deep ploughing is advisable, inasmuch as it will materially help a succeeding root crop. Catch crops are always assisted by the provision of a dressing of artificial manure where the soil is not in the best of condition. But for trifolium and vetches phosphatic manures are recommended, and for the cereals a combination, not a mixture, of phosphatic and nitrogenous manure (sulphate of ammonia),

Continued

Group 27
SHORTHAND
9
Continued from page 1163

SHORTHAND

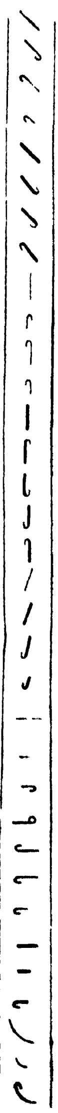
Ninth Instalment of the Special Course of Shorthand Taught by Messrs. Pitman & Sons on their Twentieth Century Plan

By SIR ISAAC PITMAN & SONS

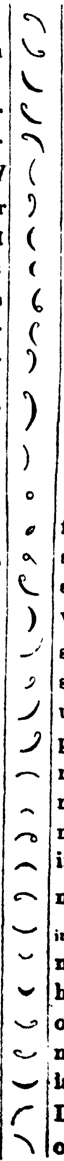
THE student has in the preceding lessons mastered a number of grammalogues, that is, words in common use which are represented by abbreviated phonographic signs. In the following list these are included, while many additional grammalogues are given, and the table should be studied and mastered in accordance with the instructions given on the next page.

Grammalogues (Phonetically Arranged). Grammalogues marked "1" (first position) are written *above* the line. Those marked "3" (third position) are written *through* the line. Those not marked (second position) are written *on* the line

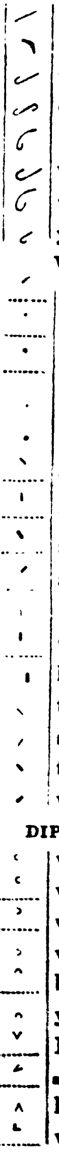
CONSONANTS.



P	happy 1; up; put 3
pn	upon
pr	principal-ly 3
prt	particular 1; opportunity
B	by, buy 1; be; to be 3
bv	above
bn	been
br	remember-ed, member; number-ed 3
T	at 1; it; out 3
tlt	told
tr	truth; true 3
trt	toward
D	had 1; do; different-ce 3
dl	deliver-ed-y
df	advantage; difficult 3
dn	done; down 3
dr	Dr 1; dear; during 3
CH	much 1; which; each 3
J	large 1
jn	general
jnt	gentleman 1; gentlemen
K	can 1; come
kt	quite 1; could
knt	cannot 1; account
ks	because 1
kl	call 1; equal-ly; called, 1
kr	care
krt	according 1
G	go, ago 1; give-n
gd	God 1; good
grt	great
F	if
ft	after 1
fr	for



fr	from
fn	Phonography
V	have
vr	over 1; ever-y
vr	very; however 3
TH	thank-ed 1; think
*th*r	through, threw 3
TH	though 1; them
tht	that 1; without
ths	those 1; this; these, 3
thr	other
thr	their, there, they are
thr	therefore 3 (double length)
S	so, us; see, use (*noun*) 3
s	as, has 1; is, his
st	first
sprt	spirit
sv	several
Z	was; use (*verb*) 3, whose 3
SH	shall, shalt
shrt	short 1
ZH	usual-ly
zhr	pleasure
M	me, my 1; him, may
mt	might 1
ms	myself 1; himself
mp	important-ce 1; improve-d-ment
mr	more, remark-ed 1; Mr, mere
N	in, any 1; no, know
nt	not 1; nature
nd	hand 1; under
nn	opinion
nr	nor 1; near
NG	language 1; thing
L	Lord
R	or 1; your; year 3



r	are; hour, our 3
rd	word
W	we
wn	one
wl	will
Wh	whether
whl	while 1
Yt	yet

VOWELS.

Dash	and (up)
ă	a, an
ah	ah!
ĕ	the
eh	eh?
ŏ	of
	on
aw	all
	awe
ŭ	but
oh	O! oh! owe
Dash	he
ŏŏ	to
	should (up)
oo	two, too
	who

DIPHTHONGS.

wĕ	when
wĭ	with
wŏ	what
wŏŏ	would
yŏ	beyond
yōō	you
ī	I, eye
ai	ay, aye (broad ai, yes)
ow	how
wi	why

By means of the directions furnished below, the table on the preceding page may be readily committed to memory. Alphabetic characters are used to represent all the grammalogues except *and*, *he*, and *therefore*, for which convenient signs are allocated.

The POSITIONS of the logograms, ABOVE, ON, and THROUGH the line, are in general determined by the vowels contained in the words; and if a word has more than one syllable, by its accented vowel. For perpendicular and sloping strokes, standing alone, the positions are

1 *ah, aw, ă, ŏ, ī, oi, wī,* ABOVE the line ; thus *at*.

2 *eh, oh, ĕ, ŭ,* ON the line ; thus *up*, *whether*.

3 *ee, oo, ĭ, ŏŏ, ow, ū,* THROUGH the line ; thus *each*.

Vowel logograms, and horizontal and half-sized consonants, have but TWO positions

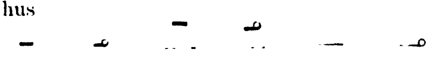
1 *ah, aw, ă, ŏ, ī, oi, ay, wī,* ABOVE the line ; as *ah*.

2 *eh, oh, ĕ, ŭ, ee, oo, ĭ, ŏŏ, ū, ow,* ON the line ; as *too*.

These rules do not apply to the irregular grammalogues set out below.

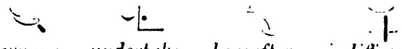
It will be noticed that in the table of grammalogues some words are indicated with a hyphen (as, *give-n*) ; or, with a double termination (as, *importan^t_ce*). The corresponding logograms represent both *give* and *given*, *important* and *importance*.

In order to mark the plural number, the possessive case of a noun, or the third person singular of a verb, s may be added to a logogram ; thus



good, goods ; God, Gods ; come, comes.

A logogram may be used either as a prefix or suffix ; thus



afternoon, undertake, hereafter, indifferent

Irregular grammalogues are of two descriptions, namely

1 Those of frequent occurrence, written ON THE LINE for convenience. These are

advantage	from	upon
are	have	usual
be	if	was
been	it	we
dear	Lord	which
deliver	Phonography	will
do	shall	your
for	think	

2 Those which, in their proper position, would clash with (*i.e.*, be mistaken for) some others. These are

any 1	much 1	this
ago, go 1	number-ed 3	those 1
in 1	O! oh! owe	though 1
me 1	over 1	truth
more 1	particular 1	with 1

EXERCISE.

Introducing the grammalogues in the preceding table. To be written in shorthand by the student, who must use the grammalogue sign for every word.

1. My dear C.,—One without principle we cannot ever call a gentleman. 2. If he has no pleasure in the good nor in the true, we do not think of his nature as great. 3. We can, however, remark that Lord W., General L., and Mr. N., are numbered as gentlemen. 4. Though there has been no particular opportunity, these have each and all had an eye to and improved on any important advantage, and been the first to give a good account of it. 5. We thank them, and remember those things, therefore, because we know them to-be not a delivery of mere words. 6. Oh! that all would do this, whether in their opinion or not there was equal advantage or no. 7. Ah! how different might things be ; what differences could be quite put out by a more happy spirit, and through the use of words or language which should give no care. 8. Why, if we have the will to deliver it, in the awe of God, this may yet be so! 9. Aye, of a truth, he himself is of this opinion ; for myself, I shall use this very language with your doctor. 10. As usual, I shall put down every word delivered in Phonography, which is of great use in my hand. 11. It is quite usual, too, for me to see not several but a very large number of those who use it, and whose principal pleasure it is to do all toward the improvement of others in it when near them, according to their opportunity. 12. It should be remembered that much was done during the first year, ay and beyond, for it is over two years ago that he told you to come or go to them when you had any difficult thing. 13. Under them our members, in a short while, I think, after the above, will equally improve much. 14. I know all will go up with us to thank him, at or from whose hands has principally been given so much, and therefore it is of importance that he should be called upon and thanked.

Writing in Position. When writing very rapidly it is impossible to insert many vowels. This has been recognised throughout, and the rules of the system have been formulated, as far as possible, with a view to the *indication* of the vowels when they are omitted. Thus, for example, it is provided that where there is an initial vowel there must be an initial stroke consonant, as in the words *ask*, *espy*,

assail, etc. And, in the same way, where there is a final vowel there must also be a final stroke consonant, as in the words *racy*, *money*, etc. In these and similar words the presence of an initial or final vowel is *indicated* by the outline of the word, without actually writing the vowel sign. Further instances of a like nature will readily occur to the student, in connection with the rules for the writing of upward and downward *l* and *r*.

In addition to the foregoing methods of vowel signification, there is the writing of consonantal outlines in *position*, by which it is possible to indicate the vowel or the principal vowel in a word. As there are three positions in which to place the vowels when inserted, so there are three positions in which to place the consonantal outlines when the vowels are omitted. The positions are named respectively *first position*, *second position*, and *third position;* the first being *above* the line, the second *on* the line, and the third *through* the line; thus 1, 2, 3,

When the vowel or principal vowel in a word is a *first-place* vowel, the outline for the word is written in the *first position*, above the line; thus *gaudy*, *dock*, *daughter*, *carry*, *laugh*.

When the vowel or principal vowel in a word is a *second-place* vowel, the outline for the word is written in the *second position*, on the line; thus *code*, *fairy*, *debtor*, *loaf*.

When the vowel or principal vowel in a word is a *third-place* vowel, the outline for the word is written in the *third position*, through the line; thus *keyed*, *fury*, *feeder*, *curious*, *leaf*.

In words consisting of a horizontal letter preceded or followed by an upright or sloping letter, the latter determines the position of the outline, the horizontal letter being raised or lowered as required; thus *pack*, *peck*, *pick*; *cap*, *cape*, *keep*. Derivative words should commence in the same position as the primary word; thus *care*, *careful*, *anyone*, *anybody*, *anywhere*, *no one*, *nobody*, *nowhere*.

There is no *third position* for words whose outlines consist of horizontal letters only, or of half-sized letters only, or of horizontal letters joined to half-sized letters. When the vowel or principal vowel in such words is a third-place vowel, the outline is written in the *second position*, on the line; thus *sank*, *sunk*, *sink*; *standing*, *tendered*, *splintered*, *gallant*, *colt*, *kilt*; *matted*, *mated*, *meted*.

Words in which the diphthong *i* is accented are written in the *first position;* as *higher*, *guidance*. Where the diphthong *ow* is accented, the outline of the word is written in the *third position;* as *prowl*.

Double-length PERPENDICULAR strokes and straight SLOPING downstrokes take only the third position, THROUGH the line; as *ponder*, *plunder*, *pounder*, *tender*, *asunder*. A double-length CURVED sloping stroke, or a straight upstroke, can be written in the three positions; as *father*, *fetter*, *future*, *latter*, *letter*, *litter*; *wander*, *wonder*, *winter*.

In words which begin with a *first-place* vowel, the insertion of the initial vowel will usually afford the greatest facility in reading. But the initial vowel need not be written in words like *arise*, *orderly*, *ask*, where it is indicated by the first consonant. It should, however, be written in such words as *apposite* (to distinguish the outline from *opposite*), *address* (to distinguish it from *dress*), *administration* (to distinguish it from *demonstration*). It is sometimes necessary also, for the sake of distinction, to insert a final vowel in words where the vowel cannot be indicated by the form of the last consonant; as *lady* (to distinguish from *load*), *monarchy* (to distinguish from *monarch*), *enemy* (to distinguish from *name*), *extricate* (to distinguish from *extract*). The student will meet with other instances where there is a liability of clashing unless a vowel is inserted. Experience only will guide him in this matter, but he should rather vocalize more freely than necessary than run the risk of illegibility.

The rules as to position are not applicable to such words as have *outlines of their own*, (which are readily recognised by their distinctive form), because the inconvenience of writing words like *dogmatic*, *Trafalgar*, etc., in the first position, and *discipline*, *Peterborough*, etc., in the third position, in accordance with their accented vowels, would not be compensated by greater ease in reading.

In the final instalment further instruction will be given, which will enable the student to read and write the Reporting Style employed in note-taking of various descriptions.

Continued

PARLIAMENTARY POWERS

Regulations and Practice in Obtaining Parliamentary Powers for Railways, Tramways, Canals, Bridges and Other Works

Group 11
CIVIL ENGINEERING
9

Continued from page 1148

By A. TAYLOR ALLEN

Parliamentary Work. Parliamentary work consists of the preparation of plans and sections for projected schemes before Parliament having reference to railways, canals, harbours, docks, waterworks, gas, tramway, and other kinds of engineering schemes.

The plan and sections should agree from actual measurements on the ground, the one being co-existent with the other, the fences and other objects being properly delineated in their lateral position, so that the engineer for the scheme, on the appearance of the petitions and subsequent efforts, may sustain the allegations against his work by the opponents to the Bill, and that his plans may successfully pass upon Standing Orders.

Parliamentary work is very rarely accomplished without the surveyor and his staff having, in some shape or form, to trespass upon the property of others, and it should be kept clearly in mind that, under such circumstances, it is essential to fulfil one's duties with as little chance of offending the owner or occupier as possible, and most assuredly to avoid doing any damage.

Qualities in the Surveyor. By courtesy and consideration in field work, the surveyor will enhance his position and command the respect of a landowner, whom, at a future date, he may meet either as a promoter or objector of the projected scheme. He must be qualified to act as witness, arbitrator, or umpire—three qualifications which demand the most careful training. As a witness, he must have clear opinions and clear reasons for holding them, and these opinions he must be able to express in concise and lucid language. As an arbitrator, he should have the qualities of an advocate, discriminating those points most favourable to his own case and lucidly enforcing them. As an umpire, he shall have the qualities of a judge, skill and judgment in weighing evidence on both sides, and in selecting only the material points.

Projected Schemes. The regulations regarding the preparation and deposit of plans and sections for projected schemes are best explained by giving extracts from the Standing Orders of the Houses of Parliament affecting private Bills:

In cases of Bills of the second class a plan and also a duplicate thereof, together with a book of reference thereto, and a section and also a duplicate thereof, as hereinafter described, and in cases of Bills of the first class, under the powers of which any lands or houses may be taken or used compulsorily, and in the case of all Bills, by which any charge is imposed upon any lands or houses, or any lands or houses are rendered liable to have a charge imposed upon them in respect of any improvement, a plan and duplicate thereof, together with a book of reference thereto, shall be deposited for public inspection at the office of the clerk of the peace for every county, riding, or division in England or Ireland, or in the office of the principal sheriff clerk of every county in Scotland, and where any county in Scotland is divided into districts or divisions, then also in the office of the principal sheriff clerk, in or for each district or division, in or through which the work is proposed to be made, maintained, varied, extended, or enlarged, or in which such lands or houses are situate, on or before November 30th immediately preceding the application for the Bill; and in the case of railway Bills, the Ordnance map on the scale of 1 in. to a mile, with the line of railway delineated thereon, so as to show its general course and direction, shall be deposited with such plans, sections, and book of reference; and the clerks of the peace or sheriff clerks, or their respective deputies, shall make a memorial in writing upon the plans, sections, and books of reference so deposited with them denoting the time at which the same were lodged in their respective offices, and shall at all reasonable hours of the day permit any person to view and examine one of the same, and to make copies or extracts therefrom; and *one* of the two plans and sections so deposited shall be sealed up and retained in the possession of the clerk of the peace or sheriff clerk until called for by order of one of the two Houses of Parliament. In cases of Bills whereby it is proposed to alter or extend the municipal boundary of any city, borough, or urban district, a map on a scale of not less than 3 in. to a mile, and also a duplicate thereof, showing as well the present boundaries of the city, borough, or urban district as the boundaries of the proposed extension, shall be deposited with the town-clerk of such city or borough, or clerk of such urban district, who shall at all reasonable hours of the day permit any person to view and examine such map, and to make copies thereof; and a copy of the said map, with the said boundaries delineated thereon, shall also be deposited at the office of the Board of Agriculture and Fisheries.

On or before November 30th a copy of the said plans, sections, and books of reference, and in the case of railway Bills, also a copy of the Ordnance map, with the line of railway delineated thereon, shall be deposited in the Private Bill Office of this House.

Tramway Schemes. In the case of Bills for laying down a tramway, an Ordnance map of the district on a scale of not less than 6 in. to a mile, with the line of the proposed tramway marked thereon, and a diagram on a scale of not less than 2 in. to a mile, prepared in accordance with the specimen to be obtained at the office of the Board of Trade, must also be deposited at that office on or before November 30th.

Electric Schemes. In cases of Bills for the supply of electrical energy, an Ordnance map on a scale of not less than 1 in. to the mile, with the proposed area of supply marked thereon, shall be deposited at the office of the Board of Trade on or before November 30th.

Tidal Lands. In cases where tidal lands within the ordinary spring tides are to be acquired, or in any way affected, a copy of the plans and sections shall, on or before November 30th immediately preceding the application for the Bill, be deposited at the office of the Harbour Department, Board of Trade, marked "Tidal Waters," and on such copy all tidal waters shall be coloured blue, and if the plans include any bridge across tidal waters, the dimensions, as regards span and headway of the nearest bridges, if any, across the same tidal waters above and below the proposed new bridge, shall be marked thereon; and in all such cases such plans and sections shall be accompanied by an Ordnance map of the country over which the works are proposed to extend, or are to be carried, with their position and extent, or route accurately laid down thereon.

Riverside Schemes. In cases where the work is to be situated on the banks, foreshore, or bed of any river, a copy of the plans and sections shall, on or before November 30th immediately preceding the application for the Bill, be deposited—

1. If the river is in England or Wales, at the office of the Board of Agriculture and Fisheries;
2. Or, if the river is in Scotland, at the office of the Secretary for Scotland;
3. Or, if the river is in Ireland, at the Irish Office, Westminster, and at the office of the Department of Agriculture and Technical Instruction for Ireland, Dublin;
4. And if the river is subject to a board of conservators, at the office also of such board.

Railway, Tramway, and Canal Bills. In the case of railway, tramway, and canal Bills, a copy of all plans, sections, and books of reference, required to be deposited in the office of any clerk of the peace or sheriff clerk, on or before November 30th immediately preceding the application for the Bill (and in the case of railway Bills also a copy of the Ordnance map, with the line of railway delineated thereon), shall on or before the same day be deposited in the office of the Board of Trade.

Local Authorities. Where, under the powers of any Bill, any work is intended to be made, maintained, varied, extended, or enlarged, or any lands or houses may be taken or used compulsorily, or an improvement charge may be imposed, a copy of so much of the said plans and sections as relates to any of the areas hereinafter mentioned, together with a copy of so much of the book of reference as relates to such area, shall, on or before November 30th, be deposited with the officer respectively hereinafter mentioned, that is to say, in the case of

(*a*) The City of London, or any borough in *England* or *Wales*, whether metropolitan or other, with the town-clerk of such city or borough;

(*b*) Any urban district in England or Wales, not being a borough, with the clerk of the district council;

(*c*) Any parish in England or Wales having a parish council, with the clerk of the parish council, or if there is no clerk, with the chairman of that coucil;

(*d*) Any parish in England or Wales comprised in a rural district, and not having a parish council, with the chairman of the parish meeting, and with the clerk of the district council;

(*e*) Any burgh in Scotland, with the town-clerk or clerk;

(*f*) Any parish in Scotland, outside a burgh, with the clerk of the parish council;

(*g*) Any urban or rural district in Ireland, with the clerk of the district council.

Deposit with State Departments. Where, by any Bill, power is sought to have any churchyard, burial-ground, or cemetery, or any part thereof, or to disturb the bodies interred therein, or where power is sought to take any common or commonable land, as the case may be, a copy of so much of the plans, sections, and books of reference required by these orders to be deposited in the Private Bill Office in respect of such Bill as relates to such churchyard, burial-ground, or cemetery, common or commonable land, shall, on or before November 30th, be deposited at the office of the Secretary of State for the Home Department, and a copy of so much of the said plans, sections, and books of reference as relates to such common or commonable land shall, on or before the said day, be deposited at the office of the Board of Agriculture and Fisheries.

Gazette Notice. Wherever any plan, sections, and books of reference, or parts thereof, are required to be deposited, a copy of the notice published in the "Gazette" of the intended application to Parliament shall be deposited therewith.

Description of Plans. Every plan required to be deposited shall be drawn to a scale of not less than 4 in. to a mile, and shall describe the lands which may be taken or used compulsorily, or on which an improvement charge may be imposed, or which are rendered liable to the imposition of an improvement charge, and in the case of Bills of the second class shall also describe the line or situation of the whole of the work (no alternative line or work being in any case permitted), and the lands in or through which it is to be made, maintained, varied, extended or enlarged, or through which any communication to or from the work may be made; and where it is the intention of the promoters to apply for powers to make any lateral deviation from the line of the proposed work.

the limits of such deviation shall be defined upon the plan, and all lands included within such limits shall be marked thereon ; and unless the whole of such plan shall be upon a scale of not less than a quarter of an inch to every 100 ft., an enlarged plan shall be added of any building, yard, courtyard, or land within the curtilage of any building, or of any ground cultivated as a garden, either in the line of the proposed work, or included within the limits of the said deviation, upon a scale of not less than a quarter of an inch to every 100 ft.

Canals, Reservoirs, and Aqueducts. In all cases where it is proposed to make, vary, extend, or enlarge any cut, canal, reservoir, aqueduct, or navigation, the plan shall describe the brooks and streams to be directly diverted into such intended cut, canal, reservoir, aqueduct, or navigation, or into any variation, extension, or enlargement thereof respectively, for supplying the same with water.

Powers for Railways. In all cases where it is proposed to make, vary, extend, or enlarge any railway, the plan shall exhibit thereon the distances in miles and furlongs from one of the termini ; and a memorandum of the radius of every curve not exceeding one mile in length shall be noted on the plan in furlongs and chains ; and where tunnelling as a substitute for open cutting is intended, the same shall be marked by a dotted line on the plan, and no work shall be shown as tunnelling in the making of which it will be necessary to cut through or remove the surface soil.

Diversion of Roads. If it be intended to divert, widen, or narrow any public carriage road, navigable river, canal, or railway, the course of such diversion, and the extent of such widening or narrowing, shall be marked upon the plan.

Railway Junctions. When a railway is intended to form a junction with an existing or authorised line of railway, the course of such existing or authorised line of railway shall be shown on the deposited plan for a distance of 800 yards on each side of the proposed junction, on the same scale as the scale of the general plan.

Street Tramway Bills. In cases of Bills for laying down a tramway, the plans shall indicate whether it is proposed to lay such tramway along the centre of any street, and if not along the centre, then on which side of, and at what distance from, an imaginary line drawn along the centre of such street, and whether or not, and if so, at what point or points it is proposed to lay such tramway, so that for a distance of 30 ft. or upwards a less space than 9 ft. 6 in., or if it is intended to run thereon carriages or trucks adapted for use upon railways, a less space than 10 ft. 6 in. shall intervene between the outside of the footpath on each side of the road, and the nearest rail of the tramway.

All lengths shall be stated on the plan and section in miles, furlongs, chains, and decimals of a chain. The distances in miles and furlongs from one of the termini of each tramway shall be marked on the plan and section. Each double portion of tramway, whether a passing-place or otherwise, shall be indicated by a double line. The total length of the road upon which each tramway is to be laid shall be stated—*i.e.*, the length of route of each tramway.

The length of each double and single portion of such tramway, and the total length of such double and single portions respectively, shall also be stated.

In the case of double lines (including passing-places) the distance between the centre lines of each line of tramway shall be marked on the plans. This distance must in all cases be sufficient to leave at least 15 in. between the sides of the widest carriages and engines, to be used on the tramways when passing one another. The gradients of the road on which each tramway is to be laid shall be marked on the section. Every crossing of a railway, tramway, river, or canal, shall be shown, specifying in the case of railways and tramways whether they are crossed over, under, or on the level.

All tidal waters shall be coloured blue.

All places where, for a distance of 30 ft. and upwards, there will be a less space than 9ft. 6 in. between the outside of the footpath, on either side of the road and the nearest rail of the tramway, shall be indicated by a thick dotted line on the plans, on the side, or sides, of the line of tramway where such narrow places occur, as well as noted on the plans, and the width of the road at those places should also be marked on the plans.

The preceding paragraph shall apply, in the case of a tramroad, wherever it is carried along a street or road.

Definition of Improvement. In the case of Bills containing power to impose on any lands or houses, or to render any lands or houses liable to the imposition of any charge in respect of any improvement, the plan shall define the improvement, and also the improvement area (being the limits within which the charge may be imposed).

Book of Reference. The Book of Reference shall contain the names of the owners, or reputed owners, lessees, or reputed lessees, and occupiers of all lands and houses, which may be taken or used compulsorily, or upon which any improvement charge is imposed, or which are rendered liable to have an improvement charge imposed upon them, and shall describe such lands and houses respectively.

Ordnance Datum and Scale. The section shall be drawn to the same horizontal scale as the plan, and to a vertical scale of not less than *one inch* to every 100 ft., and shall show the surface of the ground marked on the plan, the intended level of the proposed work, the height of every embankment, and the depth of every cutting, and a datum horizontal line, which shall be the same throughout the whole length of the work, or any branch thereof, respectively, and shall be referred to some fixed point (stated in writing on the section), near some portion of such work, and in the case of a canal, cut, navigation, public carriage road, or railway, near either of the termini. The distance of such fixed point above, or below, an Ordnance bench mark in the locality of the proposed works, and near one of the termini, and the height of such bench mark, above Ordnance datum, shall also be stated.

Improvement of Navigation. In cases of Bills for improving the navigation of any river there shall be a section which shall specify the levels of both banks of such river; and where any alteration is intended to be made therein, it shall describe the same by feet and inches, or decimal parts of a foot.

Railways. In every section of a railway, the line of the railway marked thereon shall correspond with the upper surface of the rails. Distances on the datum line shall be marked in miles and furlongs, to correspond with those on the plan; a vertical measure from the datum line to the line of the railway shall be marked in feet and inches or decimal parts of a foot at the commencement and termination of the railway, and at each change of the gradient or inclination thereof; and the proportion, or rate of inclination, between every two consecutive vertical measures shall also be marked.

Wherever the line of the railway is intended to cross any public carriage road, navigable river, canal, or railway, the height of the railway over, or depth under the surface thereof, and the height and span of every arch of all bridges and viaducts, by which the railway will be carried over the same, shall be marked in figures at every crossing thereof; and where the railway will be carried across any such public carriage road or railway, on the level thereof, such crossing shall be so described on the section; and it shall also be stated if such level will be unaltered.

If any alteration be intended in the water level of any canal, or in the level or rate of inclination of any public carriage road, or railway which will be crossed by the line of railway, then the same shall be stated on the section, and each alteration shall be numbered; and cross sections, in reference to the numbers, on a horizontal scale of not less than 1 in. to every 330 ft., and on a vertical scale of not less than 1 in. to every 40 ft., shall be added, which shall show the present surface of such road, canal, or railway, and the intended surface thereof when altered; and the greatest of the present and intended rates of inclination, of the portion of such road or railway intended to be altered, shall also be marked in figures thereon; and where any public carriage road is crossed on the level, a cross section of such road shall also be added, and all such cross sections shall extend for 200 yards on each side of the centre line of the railway.

Embankments and Cuttings. Wherever the extreme height of any embankment, or the extreme depth of any cutting, shall exceed 5 ft., the extreme height over, or depth under the surface of the ground, shall be marked in figures upon the section; and if any bridge or viaduct of more than three arches shall intervene in any embankment, or if any tunnel, height or depth shall be marked in figures on each of the parts into which such embankment or cutting shall be divided by such bridge, viaduct, or tunnel.

Tunnelling and Viaducts. Where tunnelling, as a substitute for open cutting, or a viaduct, as a substitute for solid embankment, is intended, the same shall be marked on the section, and no work shall be shown as tunnelling in the making of which it will be necessary to cut through or remove the surface soil.

Gradient in Case of Junctions. When a railway is intended to form a junction with an existing, or authorised, line of railway, the gradient of such existing, or authorised, line of railway shall be shown on the deposited section, and in connection therewith, and on the same scale as the general section, for a distance of 800 yards on each side of the point of junction.

Form of Estimate. The estimate for any works proposed to be authorised by any railway, tramway, tramroad, canal, dock, or harbour bill, shall be in the following form, or as near thereto as circumstances may permit.

Estimate of the Proposed Railway.

Line No.	Miles.	f.	ch.	Whether single or double.
Length of line				

	Cubic Yds.	Price per Yd.	£ *s.* *d.*	£ *s.* *d.*
Earthworks: Cuttings— Rock .... Soft Soil .. Roads ..				
Total				

Embankments, including roads.
Cubic yds.
Bridges—Public roads . *Number*
Accommodation bridges and works
Viaducts .. ..
Culverts and drains .. ..
Metallings of roads and level crossings
Gatekeepers' houses at level crossings
Permanent way, including fencing
Miles. fgs. chs. Cost per mile.
£ *s.* *d.*
@

Permanent way for sidings and cost of junctions .. ..
Stations .. ..

Contingencies .. .. per cent.

Land and buildings
A. r. p.

Total £

The same details for each branch, and general summary of total cost.

Continued

Continued from page 1196

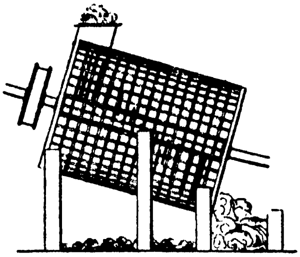
REDUCING COTTON AND WASTE SILK

The Operations of Breaking, Mixing, Opening, and Scutching Cotton. The Machines Employed. The Washing, Dressing, and Filling of Silk

By W. S. MURPHY

COTTON

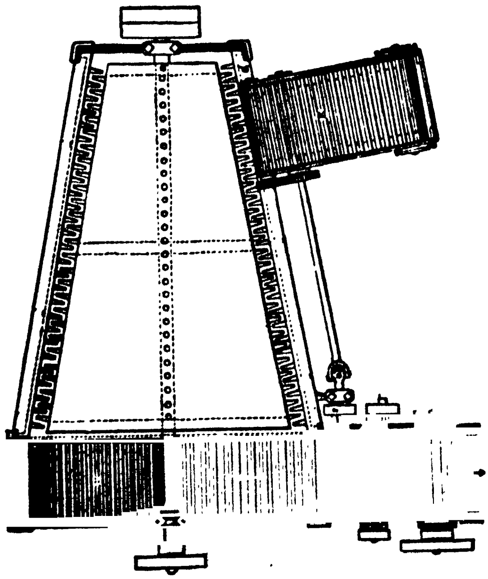
Selecting the Material. The British cotton-spinner gathers his raw material from afar, and on the cotton market the choice is wide. Here are Egyptians, brown and white; East Indian cottons ranging from medium to very coarse; New Orleans, Peruvian, West Indian, Brazilian, Sea-Island, and many other cottons, as the student already knows. The question now is, What kind of cotton do we want? Surats, Bengals, and inferior Uplands make coarse wefts; Bahia, New Orleans, Demerara, and inferior Sea-Islands form fine muslin wefts; warps are spun from Egyptians, Maranhams, Pernams, and Sea-Islands; brown Egyptian and fine Sea-Island are mixed for the finest sewing threads. The selection is varied, but the task of selecting is lightened by the fact that most manufacturers specialise in a limited range of yarns, some concentrating on fine counts, others on mediums, and a few on special classes of yarns, while the vast mass of the trade must be content with producing low counts, ranging from 10's up to 30's.



42. THE PRIMITIVE WILLOW OF NORMANDY

The best commercial results are obtained by mixing the fibres in various ranges of quality. By judicious mixing it is possible to obtain a good quality of yarn more cheaply than by using only one kind or class of cotton-wool. In the selection of cottons there are several points to be observed. Weight to length is given as the cotton-spinner's standard. That is to say, so many hanks of 840 yards each must weigh 1 lb. avoirdupois. The finer the yarn, the greater the number of hanks in the pound. Every yard of the yarn must be of the same weight. This is a very strict test of accuracy in spinning, one would think, but it does not include everything. A soft, weak yarn may have the same proportion of weight to length as a fine, strong thread. A harsh and brittle cotton may now be spun, with our delicate machinery, into a very high count. Fineness, lustre, tensile strength, and regularity are, therefore, qualities which must be considered. The best general rule is to mix fibres of the same length of staple and similar structure, combining, if possible, supplementary characters. The mixture of brown Egyptian and Sea-Island is a good example. The fine softness of the latter modifies the hardness of the former, while the great tensile strength of the Egyptian adds just the quality in which Sea-Island is comparatively deficient.

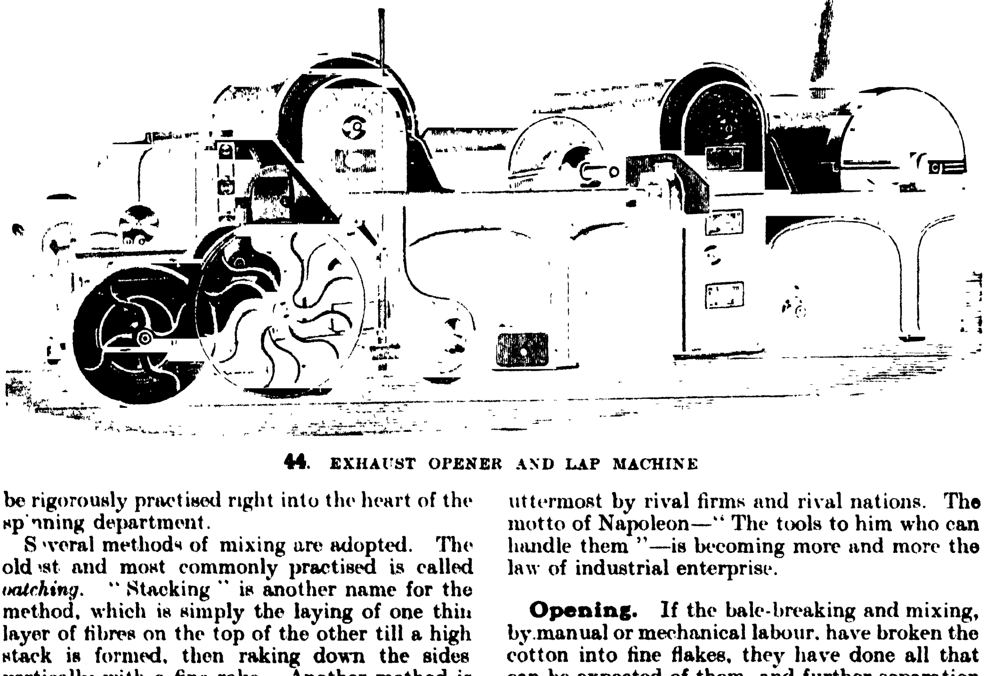
Bale Breaking. Having selected our cottons, we bring them from the stores, and proceed to break up the bales. For this purpose we have provided ourselves with a bale-breaker. Caked hard with the bale-press, the bale breaks up in lumps, and these are fed by hand on to the lattice traveller, which carries them up to the first pair of deeply fluted rollers. These move slowly, and draw the masses gently into the machine, and deliver over to another pair of rollers revolving at a higher speed. In consequence of their higher speed, the second pair of rollers drag faster than the first deliver, and thus pull asunder the clogged fibres. A third pair of rollers running behind the second pair at a rate of speed still higher, draw the staples further apart; the fourth and last pair of rollers operate in similar fashion, delivering the cotton in a fine fleecy state. While being broken, the cotton drops a marvellous collection of hard substances into the box below, varying from small pebbles



43. CONICAL WILLOW, TOP VIEW

to pieces of worn-out shoes. On this account, and to avoid injuring the fibres, the bale-breaker should be carefully used, and constantly attended.

Mixing. We have already discussed the theory of mixing, and now come to the practice. There is one difference in cotton fibres which is above and beyond all the selective power of man, and we must refer to it briefly. Cotton is a natural product, and Nature does not act on mechanical lines, but on vital principles. Examine, even with the naked eye, a staple of cotton from a single pod, and you will see that the fibres are in different stages of ripeness; some are beautifully flanged, like symmetrically curved ribbons; others are straight tubes, with the vegetable sap yet in them. Unless these fibres can be very intimately mixed, we cannot obtain from them a uniform yarn. Mixing the fibres is only the first of the devices by which the cotton-spinner endeavours to combat this obstinate fact. Combine differences to make a uniform average; that is the rule, and it must be rigorously practised right into the heart of the spinning department.



44. EXHAUST OPENER AND LAP MACHINE

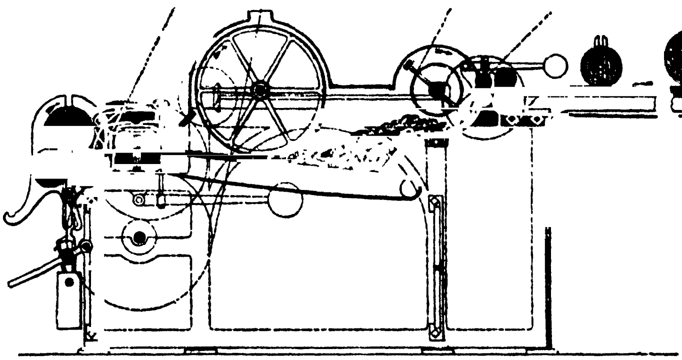
Several methods of mixing are adopted. The oldest and most commonly practised is called *matching*. "Stacking" is another name for the method, which is simply the laying of one thin layer of fibres on the top of the other till a high stack is formed, then raking down the sides vertically with a fine rake. Another method is practised in certain mills which, we think, have the future with them. The object of these mills is to dispense with human labour to the very utmost. From the bale-breaker the cotton is carried on lattice travellers that branch off in different directions, and at the end of each branch revolves a scoop, so tilted that all it receives is dropped on to the floor beneath. The speed of these scoops is varied, now quick, now slow, and the area over which the cotton is distributed varies with the centrifugal force of the revolving scoop.

When different fibres are to be combined in one yarn the mixing is sometimes deferred till the scutcher is passed. A soft fibre needs to be much more gently treated in the opening and scutching than a strong, hard fibre. The cotton-wools are therefore brought separately through to the lapping machine, which is then operated as a special machine, and there combined, to be ready for the carding. But this method cannot be detailed further, because understanding of it pre-supposes knowledge of processes not yet studied. The fact is mentioned to indicate the resources the ingenious mind discovers in processes apparently simple and almost inevitably routine.

In textile manufactures, not less than in any other human pursuit, resourcefulness carries a man forward to success. Never before in the known history of the world was there such a premium on fertility of resource in the minds of industrial workers. Every detail of every manufacturing process is being searched to the uttermost by rival firms and rival nations. The motto of Napoleon—"The tools to him who can handle them"—is becoming more and more the law of industrial enterprise.

Opening. If the bale-breaking and mixing, by manual or mechanical labour, have broken the cotton into fine flakes, they have done all that can be expected of them, and further separation of the fibres must be accomplished by other means. For this purpose a number of machines, variously named openers or willows, have been developed in a way very interesting in its early stages. The first invention was a bench, the table of which was formed by a tightly drawn netting of cords. On this table the cotton was spread, and beaten down with willow wands. Next, a man named Bowden contrived a machine by which a series of parallel rods were made to strike the cotton on the netting in rapid succession. On the other hand, however, the natives of Normandy had long used a machine composed mainly of plaited willows. "This," says Dr. Ure, "is undoubtedly the original of the English willow, both in form and denomination."

Dr. Knight says that the name given to the opener is wholly of English origin, and is simply a transfer from the willow-wand beaters on to the machine which performed the beating. We need not trouble about names; the fact remains that this old cone willow [42] contains within it the principle of all the openers since invented. Within the wattle cylinder was set a spindle carrying a series of spikes extending at right angles and graduated in length, the longest at each end and lessening in size to the middle. The cylinder was set at a slant, and on the top end was a hopper, into which the cotton was fed. Put in motion by hand or power, the spikes whirled round, beating the cotton against the sides of the cylinder, causing the dust to fly out through the open wattle, and delivering the cotton at the lower end.



45. COTTON-SCUTCHER

Later machines, of which there is a large variety, are more or less successful adaptations of the principle exhibited in that ancient contrivance. Typical models are the following:

46. MODERN SCUTCHER (Platt Bros. & Co., Oldham)

Cone Willow. A cone-shaped cylinder [43] hung horizontally within an iron casing, the outer surface of the cylinder and the inner surface of the casing studded with spikes, form the main working parts of this machine. The cylindrical cone is geared on a spindle to revolve at high speed; the casing is stationary, and its under part is an iron grid or netting. At the wide end of the cone a fan revolves above a whirling dust cage, causing a suction of air and driving out the dust. When the willow is set going and the cotton fed into the narrow end on the travelling lattice, the spikes on the cylinder and the casing pull the cotton open, while the whirling motion of the cone and the suction of the fan cause the fibre to wheel slowly down to the wide end of the cylinder, where it is received by another travelling lattice and borne outward. Teased open by the spikes and beaten hard against the grid, the cotton is made fleecy, clean, and white.

The Oldham Opener. Probably the oldest of English willows, this machine is still used for coarse cottons of a dirty class. The cylinder is roller-shaped, and so is the casing. The lower side of the case is a semi-circular cage or grid, the front half opening and closing on hinges. The cotton is fed into the opened grid, which is then closed, and the machine started. When the fibres have been sufficiently opened, the grid is lowered and the cotton thrown out. Improved models of this willow have been put on the market, advantage being taken of the rising and falling of the grid to measure by weight the quantities of cotton opened.

The Crighton Opener. The inventor of this machine had evidently paid special heed to the form of the old Norman willow. His invention, at all events, is a very close adaptation of the primitive willow. Instead of a solid, cylindrical cone studded with spikes, the

Crighton opener has a cone grid enclosing a spindle with beater arms conically graded, the cones being set apex downwards. Fed through separating rollers, the cotton passes into the wide end of the cone beaters through tubes, and goes whirling round, flying from grid to beaters, and beaters to grid, till it reaches the bottom, where it is drawn off, speeded by the fans from whose wings a constant stream of air rushes through the machine.

Exhaust Opener. The student should now be fairly well acquainted with the functions discharged by the various parts of an opener, or willow, and we therefore contentedly quote the account the makers give of this machine: "The cotton is taken from the mixing and spread on the lattice of the feeder, the feeder having collecting roller, two pairs of feed rollers, and cylinder, which deliver it to the dust trunks, over which it is drawn by the action of the exhaust fan into the cylinder of the opener. The loose dust is deposited in the dust trunks, and the cotton enters the cylinder of the opener by tin pipes, and after passing the cylinder is spread level on the first pair of cages by the action of the two exhaust fans. It then passes through the cages and two pairs of feeder rollers, is then subjected to the action of a three-wing beater, and is made into good level laps, thus obtaining the greatest amount of cleaning with the least damage to, and without stringing, the fibres of the cotton. By the use of two fans the cotton is spread level upon the cages without having to use dampers. At the commencemen of each lap the rollers at the feeder are started a short time before the lap part of the opener, and at the finish the feeder stops the same length of time before the lap part. By this means the trunks and pipes are freed from cotton when the lap part stops, and this obviates any irregularity arising from the cotton remaining in the trunks. The connection between feeder and opener is automatic in its action, and requires no attention."

Scutching. At this point, cotton-spinners who have been paying little or no attention to weight must begin. From the scutcher the cotton passes to the carder, and then there is no drawing back, except at great cost. The weight to length of a given fineness of thread has been inevitably determined. No matter how irregular the laps, the carder will inexorably reproduce every defect in the sliver, and it will go on through the whole range of spinning machines, recording the error as mercilessly as the Book of Life itself.

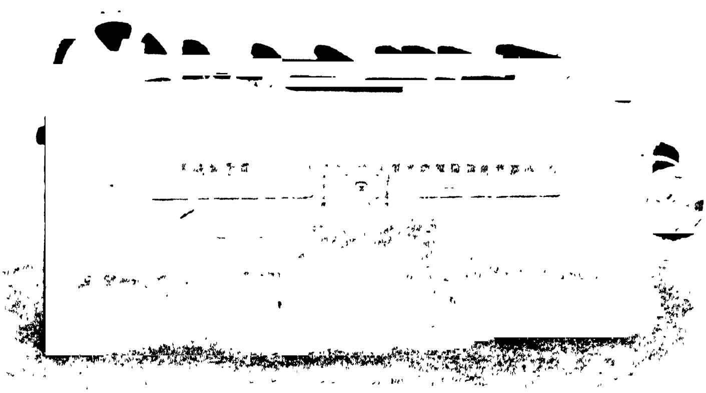
The Scutcher. There is only one scutcher though there are many different makes and numerous small improvements. In the feeding gear especially we have been greatly assisted by machine makers. Originally invented by Snodgrass, of Johnstone, N.B., and improved by Peter Cooper, of Johnstone, Crighton, of Manchester, and many other machinists, the scutcher is one of the most important machines we have. It can be adjusted to work upon any class of cotton, and produce any weight of lap required. At the fore end of the machine [46] is the lattice feed, curiously regulated by what has been called the "piano" motion. Let us explain. The area to be covered by the cotton taken in at one time is gauged on the feed-board, and it falls into gear only when the weight has been supplied. This delicacy of feed may seem adequate for many purposes, but it is not accurate enough for the cotton-spinner. A wooden roller controls the feed, and under this roller we have a series of vertical bars connected with the cone which regulates the speed of the roller. If the layer of fibre be too thick these rods instantly cause the speed of the roller to be reduced; if too thin the speed of the roller is quickened by the same automatic agency.

From the wooden roller the cotton is taken

47. COTTON AFTER SCUTCHING

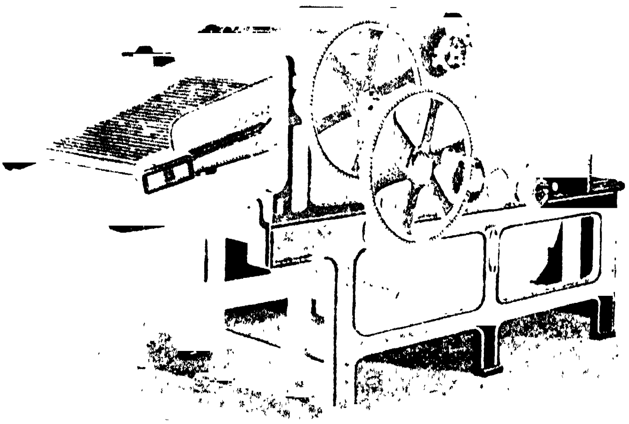
into the machine by a pair of deeply fluted rollers, and delivered over to the beater, running at the rate of 2,000 revolutions a minute, batting the fibre with its flat ends against the curved grid below, and driving out the dust. The fans are blowing hard, and waft the fleecy wool along the endless lattice to the sieve cylinder, which sucks the dust through while sending the cotton on to the second beater, revolving more rapidly than the first, upon another grid. Thence the fibre is taken hold of by another air-sucking cylinder sieve and sent forward to the lap-forming apparatus.

Though still hidden within the machine, we know that the cotton is now a fleecy mass or layer lying loosely on the conveyor. Carried forward under a guide roller, it is made to enter the first of two pairs of heavy iron rollers, which compress and firm it, while delivering to the wooden lap cylinder. Note the heavy weights on the axis of the roller [45], bearing it down upon two other rollers revolving in the same direction upon it. As the lap roller increases in thickness, the angles of the weights change, so that the pressure continues uniform. When the layers of cotton have reached the proper thickness, the whole machine, from the first pair of rollers backwards, momentarily stops, while the second pair of heavy rollers, and the rest of the lapping apparatus, run on, causing the lap to break off. The lap roller automatically descends and gives place to the one hung above, and sits waiting the call of the carder. Scutching operations have again been resumed.



49. SILK DRESSING MACHINE

Throughout our study of this process we have kept strictly to common practice. By taking the highest here and there, it is quite possible to build up an ideal cotton factory; but, so far as we have seen, the possible perfection has not been attained. Every cotton factory could be made practically automatic from the bale-breaker to the carder—at least, such automatonism as has been made from the carder onward can be attained. By wise use of the microscope and the micrometer at the bale, by careful adjustment of machine to machine, and machine to productive need, the end can be gained. By this we do not mean to displace labour; the worker will always be needed in every department of the cotton factory, but his function will be higher and better paid. It is in the direction of increased efficiency and exercise of higher intelligence that the worker must look for an amelioration of his lot, so far as it can be improved in the industrial sphere. The British workman has no superior on the face of the earth when he chooses to use his brains.



48 SILK FILLING MACHINE

SILK

Washing and Dressing Silk Waste. Raw silk comes to this country chiefly in the form of a thread, and therefore does not enter into this stage of our study. With silk waste the case is different. Silk waste is as much a raw fibre as either wool or flax, and requires treatment resembling in several respects the preparatory processes to which both these fibres are subject. Silk is among textiles what gold is among metals; it exercises a magical charm over the minds of men. After Lord Masham's famous experiment, hundreds of textile manufacturers sought to devise for themselves methods of utilising waste silks. The consequence is that we have several different processes with machines corresponding. It is impossible in this course of study to view every variation in textile manufacturing processes, and it is only fair to admit that ours is only one or two out of many processes. In some factories all silk waste is treated alike, but we think the better plan is to make a difference between cocoon and other wastes.

Treating the Cocoons. The waste from cocoons consists of broken cocoons, rough floss, unreelable knubs, and other material of similar kind. A hot solution of soap is prepared in a laundry washing machine, or dollying tub, and into the liquid the cocoon waste is put. By a simple mechanism the stampers are lifted and let fall, while the tub revolves on a tooth and ratchet arrangement. The heated liquid, with its strong detergent properties, aided by the elastic pressure of the wooden stampers, or dollies, drives out the dirt and gum. It is a simple operation, but care has to be exercised. The stampers may bruise the fibres, and the caustic of the soap may shrivel them. With a reasonable amount of care, however, we can get clean and good fibres from this tub to put into the one next it—a cold washing machine, in every way similar, excepting that a continuous stream of water runs through. The washing done, we pour the cocoons into a hydro-extractor. This is a form of drying machine, born long after the main processes of textile manufacture were determined, and therefore little used among us. Enclosed within a round iron tank, from which a waste pipe protrudes, is a wide basket composed of closely woven wire. Placing the wet silk in the wire basket, we put on the drive. Slowly for a moment, but quickly gathering enormous velocity, the basket whirls, the motion driving the moisture through the sieve into the outer tank, drying the cocoons with great rapidity.

Next, the cocoons have to be loosened so that the threads will float free. Sometimes this is done simply by beating; but a good machine has been invented for the purpose. Over a revolving tray is geared an endless band, to which a series of belts is attached. Laid on the tray, the cocoons are subjected to a rapid succession of whips from the flying belts, and effectually beaten loose. In this condition this section of the waste can be allowed to wait, for study purposes only, of course, till the other section is brought up to the same pitch of preparation.

Washing the Waste. The greater portion of the waste is a gummy mass of tangled material, scarcely recognisable as silk. When first the waste began to be utilised, it was boiled till all the gum was dissolved. Some silk manufacturers still favour the boiling process, believing that it is gentler on the fibres than any other method. Though boiling may produce good results, the process has been largely discarded in favour of retting. The masses of waste are immersed in shallow tanks containing a soapy solution. Along the bottom of each tank a coil of steam-pipes is laid. Firmly closed, the tanks are heated up to 170° F. by steam introduced into the coils, and the mixture allowed to ferment.

If injury to the fibres is to be prevented, the closest watch must be kept, and when sufficiently retted the waste should be lifted out and plunged swiftly into a dolly-tub containing a warm solution of soap. The least delay in carrying out these acts brings serious consequences, for the slimy substance bred in the fermentation hardens at once and becomes utterly insoluble.

The washing and drying of this waste differs in no important particular from that carried out on the waste cocoons.

Teasing. When silk waste first began to be utilised, it was thought that nothing less violent than the rag-tearer of the shoddy manufacturer would serve to break up those tangled masses; but of late gentler methods have been found to answer the purpose better. In some places, the wool-opener is used, and in others the "fearnought"; but the latest filling engines, allied to the thorough washing we have just seen, are the only instruments needed to disentangle the fibres.

Filling. Machine makers offer several kinds of filling engine. Some have feeding bands covered with little teeth, to hold the fibres; others have fluted drawing rollers, for the same purpose; but the engine we illustrate is among the newest models [**48**]. Laid on the travelling lattice, the fibres are borne into touch with the first of a set of rollers closely covered with little teeth that drag and pull out the tangles. Passing through combs, carried off on spiky rollers, smoothed out by roller brushes, the silk waste at last is dragged on to the large cylinder studded with rows of spikes on which it is cut to lengths of about 3 in.

Another machine much used is very direct in its action and easily worked. The feed cloth is covered with little spikes that, while feeding, drag out the silk. Two tooth-covered rollers take on the fibres, one after the other, and, being run at different speeds, pull it out. At the back of the machine is the huge cylinder, with spikes set at intervals of three or four inhes across its breadth. Driven at a moderate speed, the spikes come round and insert themselves into the tangles of silk, and pull out a range of threads. Every row of spikes takes a share, and the cylinder thus becomes clad with silk fibres. The attendant of the machine cuts out the spoil carried by the spikes, and forms them into what are called *stricks*, the breadth of the cylinder, and each fibre the length of the interval between the spikes.

Whatever may be the form of the filling engine, its main object is to card out the fibres and cut them down to a length suitable for passing through the spinning machines constructed for fibres of moderate length. If the machine accomplishes that purpose, we should venture to think that its principle of working can hardly be strange to us.

Dressing. The dressing machine is a remarkable contrivance, original in conception and highly efficient [49]. First we take the *stricks* derived from the filling engine, and fix them into wooden clamps, technically called "books." These are fixed into the bed of the dressing machine. Observe on the machine a broad, endless band, stretched between two heavy rollers, and upon the band at short intervals, belts of heckle teeth, named combs. When the stricks are properly set and the machine running, the band brings those combs through the fibres, and they take away as many short or doubled fibres as will come, while finely dividing and combing out the fibres that remain. After a time the combs come away clean, showing that the silk has been sufficiently treated. Now stop the machine and lift out the clamps. The fibres there are said to be the first draught, and are of the highest quality. From the combs the fibres are cleaned and put into the wooden clamps on the bed of the machine. The travelling combs gently, but firmly, pull out the shorter silk threads, leaving in the clamps those which are of sufficient length and regularity to take the combing without yielding. These fibres are named second draughts, and rank second in quality. The process is repeated another three or four times, and nothing is left save the very short fibres, which, under the term noils, pass through the common carders in a manner we shall study shortly.

Improved Machines. Makers of machines for every department of the textile industry are constantly devising new things. Silk dressing is no exception, and it is quite impossible for practical men to keep pace with the inventors. One of the machines which has come lately into use is worth noting, because of its special character. In this contrivance, the main features of which are three cylinders, the stricks are wound on to wooden rods, which are clamped on to the centre cylinder. A huge affair this central cylinder moves slowly and majestically round, while the two side cylinders, clothed with serried teeth, run in opposite directions at a good speed. The motion of the two outside cylinders is always opposite to that of the centre cylinder, and the teeth, therefore, pull at the fibres fixed on its surface. After one end has been combed, you simply remove the rods, reverse the fibres, and fix them in again while the machine is running. The machine is certainly simple and very easy to work.

Automatic Dressing. In the great silk works at Manningham, the aim of automatic perfection is steadily pursued. Here, instead of being cut into stricks at the filling engine, the fibres are formed into a lap on the opener or willow. These laps are laid on a feeding table, with a rocking filling head. Parallel with the table is a moving comb. With the forward movement of the rocking filler the fibres are thrown on to the comb and pulled. As the rocker falls back, a knife comes down and severs the taut fibres. The comb moves forward, to traverse three machines in a similar way, and then from above and below come sets of nips which take away the fibres and, on endless bands, convey them to the carding cylinders. Borne on to the end of the series, the fibres are finely dressed and ready for being formed into slivers.

Wild Silks. Up to the time when the process we have examined had come into general knowledge many of the "tusseh," or wild silks, of China, India, Japan, and America, though sometimes reeled and worn by the natives of the East, were almost wholly disregarded by the silk workers of Europe. The yamamai of Japan, the ailanthus of Chefoo, and several of the Indian wild silks, though true tussehs, were reeled and thrown by Europeans, but the greater number of the varieties of that class could not be utilised among us, because of the cost the reeling involved. The waste-silk process has completely obviated the difficulty presented by the tangled and gummy cocoons. By treating the wild silks in the same way as the broken cocoons and knubs of the cultivated varieties, we obtain silk yarns of a very high quality. Indeed, it is sometimes asserted that some of the tussehs so treated are equal in lustre and other qualities to the very finest of the cultivated kinds. We hardly venture so far. For one thing, the wild silks give more anxiety and trouble to the dyers and bleachers, many of them being of an indelible brown shade. It is true that methods of bleaching them have been devised ; but these methods involve both trouble and expense. Even so, the waste-silk process has in this manner vastly enlarged the sources of silk supply. If the silk industry of Great Britain were to renew its former prosperity, the vast numbers of wild silkworms in Indian forests would be properly utilised. Tusseh cocoons, as we have hinted, are treated like the broken cocoons of the cultivated varieties. We hardly need, therefore, go over the process again.

In some degree our study of silk waste has carried us beyond the precise limits of purely preparatory processes, and led to trenching somewhat on the carding and combing processes, which should be studied thoroughly by themselves. The carding proper of silk waste has yet to come, however, and then that class of fibre will fall into line with the others.

Continued

Continued from page 1134

OUTLINES OF EDUCATIONAL TOURS ABROAD

Itineraries of Travel in Austria and Hungary. A Guide to the Art Treasures, Historic Sites, and Scenic Beauties of these Countries

By J. A. HAMMERTON and WILLIAM DURBAN, B.A.

AUSTRIA

Austria is an ideal country for the intelligent traveller. This great section of South Central Europe is more composite in its nationalities than any other portion of the Continent, and all its diverse populations are extremely interesting. Here ancient and modern history blend in almost bewildering combination, so that the tourist's attention is constantly invited to the consideration of strange contrasts. Austria has only recently begun to receive the acknowledgment it merits as a resort for travel, study, health, and recreation. The mighty Danube and its tributaries, the majestic mountain ranges, and the exquisite lakes, all lie within easy compass, so that nowhere is a delightful tour more conveniently to be arranged within the scope of a brief holiday season. The wonderful mountain scenery includes the Ortler Group, the Carinthian and Styrian Alps, and many of the grandest of the Dolomite peaks. Much of the famous and incomparable Tyrolese region is within the Austrian Empire, and many of the lakes are of the utmost loveliness. Travel in Austria is now greatly facilitated and economised by the zone system, as well as by the arrangements made under the bureau of the State railways, which gives courteous and specific information as to conditions and fares. *A week in Austria* is often snatched by those whose main object is to visit Germany, or Italy, or Switzerland. Such an interlude affords a delightful opportunity of making acquaintance with Vienna, and with a few of the beautiful Danubian cities, such as Passau, Linz, and Presburg. But more than this is not possible.

A Fortnight in Austria. Two weeks enable one to see a good deal of the country, and can scarcely be excelled as a holiday. The spots to be visited are full of the most varied fascination.

FIRST DAY. The traveller most conveniently commences with PASSAU, which he reaches by rail from Munich, or else from Nuremberg through Ratisbon. At the charming old city of Passau we strike the Danube and cross the Austrian boundary. This is one of the most beautiful spots on the whole course of the great river. The striking confluence of the Danube, Inn, and Ilz. Lovely views from the heights near the banks of these rivers. *Cathedral of St. Stephen*, one of the finest of all ancient Teutonic churches, founded in the fifth century. The *Parade Platz* in front of the Cathedral, with great bronze statue of Maximilian I. The noble *Rathhaus*, or town hall, with council chamber embellished with historic pictures. The quaint, ancient churches of the *Heilige Kreuz* and *Maria Parz*, the latter containing the tomb of Abbess Gisela, Queen of Hungary.

SECOND DAY. This would be spent in the beautiful environs of Passau. The pilgrimage church of *Maria Hilf*. The fortress of *Oberhaus*, in a romantic spot by the Ilz. The *Ilz Bridge* and the *Belvedere*. The *Klosterberg*, with wonderful views.

THIRD DAY. Steamboat journey to LINZ. Scenery grander than that of the Rhine, the noble stream winding its way through precipitous wooded hills, with rich vineyards on the lower slopes. Linz is reached in the evening.

FOURTH DAY. Linz is a beautiful and characteristic Austrian city, and the capital of Upper Austria. Splendid *bridge* over the Danube. The fine *Haupt Platz*, in which rises the lofty Trinity Column. The noble thoroughfares of the *Klostergasse*, the *Schmiedt or Gasse*, the *Dom Gasse* and the *Land Strasse*. The ancient *Cathedral*. The new and beautiful Gothic *Cathedral*, with votive chapel richly decorated with marble mosaics, gilding, and stained glass. Short trip to the *Postlingberg* and the pilgrimage church of *St. Magdalena*, from both of which are obtained magnificent views of the Danube and the country.

FIFTH DAY. Another glorious day's ride through some of the most fascinating scenery in Europe is obtained by going from Linz to VIENNA, on the Danube. Everywhere are dotted romantic old castles perched on picturesque crags. Near the island of *Worth* is the *Greiner Schwall* (surging water), and further on is the famous "Strudel" or whirlpool. The day's voyage is a memorable one.

SIXTH DAY. The city of VIENNA is on the Wien, a short distance from the Danube. Many days might be spent here, for so much is to be seen. The Church of St. Stephen, the *Cathedral* of Vienna, the Giant's Door and the two towers called the Heidenthürme. The famous chapel of St. Barbara; the Thekla Choir, with the beautiful sarcophagus of Kaiser Frederick III.; the famous pulpit in the nave; the great catacombs under the church; the tower of St. Stephen with grand view of the battlefields of Lobau, Wagram, and Essling.

SEVENTH DAY. On the second day in VIENNA, visit the *Graben*, the chief business street, formerly the great moat, now containing magnificent shops, and in its central portion the lofty *Trinity Column*. The *Hofburg*, or Royal Palace, with monument of Francis II, and the splendid statues of Joseph II, Archduke Charles, Prince Eugene, and Francis I. In the Hofburg are the vast *Imperial Library* and the famous Treasury, full of precious jewels, regalia, and priceless historic relics and curiosities, including the crown of Charlemagne, and the celebrated Florentine diamond. The *Imperial Picture Gallery*, with masterpieces of nearly all schools. Grand specimens of Titian, Raphael, Correggio, Parmigianino, Giorgione, Dürer, Rubens, etc.

EIGHTH DAY. A third day would be devoted to the sights of the city. *Academy of Art*, with wonderful picture galleries, containing famous pictures by nearly all the great artists of various countries, the most famous being the "Cupid" of Titian, the "Two Boys Playing at Dice" of Murillo, the "Boreas" of Rubens, and several landscapes of Ruysdael. The *Ring Strasse* and the *Franz Josephs Quai*, which together encircle the inner city and form one of the most imposing streets in all Europe. The magnificent buildings to be inspected are the *Exchange*, the *Handels Museum of Manufactures*, the beautiful Gothic church called the *Votivkirche*, the splendid *University*, the sumptuous *Rathhaus*, the *Historical Museum*, the *Hofburg Theatre*, richly adorned with paintings, the *Houses of Parliament*, the *Palace of Justice*, the grand *Maria Theresa Monument*, the *Natural History Museum*, the *Art-History Museum* the *Imperial Opera House*, and the *Museum of Industry*.

Ninth Day. The outer districts of Vienna contain a world of interest in themselves. A delightful half-day may be spent in the celebrated park and forest called the *Prater*, in which the Haupt-Allee, or principal avenue, with its quadruple row of grand old chestnut-trees, is Vienna's most fashionable suburban resort. In the north-western part of Vienna are many interesting old streets, adorned with picturesque statues, fountains and churches, and with the quaint old *Palace and Picture Galleries of Count Harrach*, to which is attached the beautiful *Winter Garden*.

Tenth Day. Journey to Botzen. This is a long, but most interesting day's ride through one of the most picturesque regions of the Austrian Empire. It brings the tourist into the very heart of the beautiful Austrian Tyrol, and lands him in the delightful old city of Botzen, situated in the midst of the glorious Tyrolese Alps.

Eleventh Day. At Botzen the tourist is at the gateway to some of the most superb scenery of Central Europe. See the Gothic *Parish Church* with beautiful open tower: the *Franciscan Monastery*; the *Calvarienberg*, a delightful little excursion commanding splendid mountain views.

Twelfth Day. Glorious ride over the *Brenner Pass*, by the highest mountain railway in Europe, and through scenery that is indescribably beautiful, to Innsbruck.

Thirteenth Day. At Innsbruck the tourist is in the capital of Tyrol, and he is at once fascinated with the attraction both of the city itself and of its glorious situation, 2,000 ft. above the sea-level, in the midst of a circle of majestic mountains. The great sight of the city is the *Hofkirche*, containing the world-famed and sumptuous monument to Maximilian I, which occupies all the centre of the nave. The church also contains a marble monument of Andrew Hofer. The neighbourhood of Innsbruck affords a great choice of charming little excursions.

Fourteenth Day. The traveller will leave Austria by taking train to Munich.

Longer Tours. If *three weeks* can be devoted to a tour in Austria, the third week should include visits to Salzburg and a few of the beautiful lakes, such as the Achensee, the Kammersee, the Traumsee, and the Wallersee. A *month* would enable the visitor to include an extension into Bohemia, taking in not only the quaint, historic capital Prague, but also such beauty spots as Pilsen, Marienbad, Siebenberge, Eger, Karlsbad, etc.

Travel and Food. Travel in Austria is rendered somewhat expensive from the fact that the leading coin, the kroner—equivalent to about two shillings—does not go much farther than does the shilling in England. Also the railway fares from Austria are somewhat higher than in Germany. Meals in Austria are somewhat luxurious. Fruit is very abundant and delicious, and fine caviare (the roe of the sturgeon caught in the Danube) is a common commodity. Nowhere can better coffee be obtained than the decoction prepared throughout this country. It is served with whipped cream, and is styled "Kaffee mit Obers."

Fares. The fare from London to Vienna is: First class, single, £7 9s. 8d.; return, £11 12s. Second class, £5 4s. 5d.; return, £8 1s. 6d.

Books. Much interesting literature of Austrian travel is current. Amongst the best books in the category may be mentioned Mrs. Donner's "Down the Danube," Browning's "Girl's Wanderings in Austria," Reeve's "Residence in Vienna," Hodgson's "Wanderings through Unknown Austria," Tissot's "Unknown Austria," McCracken's "Tyrol," etc.

HUNGARY

The famous land of the Magyars is, in natural resources, one of the richest sections of the Continent, and it is, in manifold respects, one of the most interesting. Hungary constitutes in area the larger portion of the great dual Empire-Kingdom. It is a country of ancient historic romance. The regions of the Huns must ever attract lovers of history and literature. The wild beauty of the Carpathians is, year by year, admired by an increasing number of tourists. Hungary owns the most picturesque reaches of the noble Danube. The vast and fertile wheat-growing areas of the "black earth" plains form a unique feature. The fascinating character of the peculiar races—Magyars, Slovaks, Croats, Dalmatians, Ruthenians, and Zingari (gipsies)—is acknowledged by all visitors. English people are always specially welcome in Hungary. The popular sense of gratitude to our nation for sympathy manifested in the days of Kossuth is as lively as ever. Very memorable is a visit to any Hungarian town or village on any national feast day. The beautiful tsardas, or national dance, is performed with singular grace.

Travel and Food. Travelling in Hungary used to be inconvenient and expensive, but the adoption of the zone tariff has entirely changed the conditions. The land is one of great fertility. Fruit and all kinds of provisions are abundant and cheap. The inns are almost everywhere exceedingly comfortable, the domestic life of the people being of a high standard. Hungary is a great wine-producing country. The traffic on the Danube and on the rivers Theiss, Drave, and Maros is immense, and the accommodation on the fine steamers for both night and day voyages is excellent. No country supplies pleasanter conditions for the tourist. Many of the customs of this interesting country are altogether unique. The visitor finds himself amongst a most hospitable and genial people. He is presented with many dishes he never saw elsewhere. The famous "paprika," a generic term for game or fowl prepared with a mild species of red pepper, is one of the national viands constantly in evidence. The people revel in delicious fruit, and the land overflows with plenty. In almost every large restaurant bands of "zingari," or gipsy wandering musicians, perform. These play the most weird music with remarkable skill, and the itinerant orchestras are exceedingly popular.

A Week in Hungary. This is frequently spent by tourists as an extension of an Austrian tour. It is naturally occupied in voyaging down the Danube, a stay of a few days at Buda-Pest, and a further passage down the great river as far as Orsova.

A Fortnight in Hungary. This is a delightful experience, as it affords time for viewing some of the most picturesque features of this remarkable country.

First Day. The steamer leaves Vienna at 7 a.m. for the twelve hours' sail down the glorious Danube to Buda-Pest, which is reached at 7 p.m. This is one of the most charming river trips in the world. Indeed, it is hardly excelled by an experience of the kind anywhere. Historic spots abound on the banks.

Second Day. Pest is one of the most charmingly situated cities of Europe. It is on the north bank of the Danube, Buda being on the south. Pest is one of the great historic cities of the continent, as it was founded by the Romans and was the scene of tremendous struggles with the Turks. It is to-day the seat of the wonderfully prosperous grain-trade of Central Europe. Splendid modern buildings adorn the grand quays of the Danube and many of the modern streets. The fine *Academy*, including the National Picture Gallery. Among the many masterpieces of various schools are six splendid pictures by Murillo. The beautiful promenade along the Danube, known as the *Franz Josephs Quai*, the old Gothic *Stadt Pfarr Kirche*, the famous colossal *corn elevator*, the fine *Custom House*, should be seen the first day. Early in the morning, every day in the week, the interesting open-air fruit and vegetable market is in full swing on one portion of the quay. The peasants and farmers attend in great numbers, in their quaint national costumes.

Third Day. On the second day in Pest visit the *National Museum*, full of superb local antiquities. The picture gallery contains 600 paintings, mostly by modern Hungarian artists, including Munkacsy. The *Parliament House*, the *Cemetery*, containing monuments of Batthyany, Deák, and other patriots, and the splendid *bridges* over the Danube—magnificent works of engineering—will make a full day's sightseeing.

Fourth Day. Excursion in morning to the lovely *Margarethen Insel*. This little island in the midst of the Danube is a great "cure" resort as well as a popular garden. It contains famous thermal establishments, and also wonderful natural hot sulphur baths, and at the luxurious *Bad Haus* are also electric and other medical baths. The afternoon may be devoted to a delightful excursion by carriage to the park in the environs of Pest known as the *Stadtwäldchen*. Here are noted concert halls and restaurants on the pretty islands in the lake.

Fifth Day. The tourist would now direct his attention to Buda, the twin capital on the opposite bank of the Danube, called Ofen by the Magyars; a magnificent old town. Visit Maria Theresa's beautiful palace; lovely view from the gardens. In this palace are kept the splendid objects belonging to the Hungarian regalia, including the famous crown of St. Stephen. The interesting *Palace Bazaar* on the quay, with fine view of the Danube. The celebrated *Matthias Kirche*, the Cathedral of Buda, which was used as a mosque by the Turks. The present Kaiser-King Franz Joseph and his consort, Elizabeth, were here crowned in 1867. The famous sulphur baths of the Danube at Buda are much frequented. The *Kaiserbad*, with its eleven very hot springs, is the most popular.

Sixth Day. A second day is necessary to see Buda. The magnificent *Blocksberg*, an immense crag by the Danube, crowned by the imposing citadel, with enchanting views from the top. The famous and curious *Turkish Mosque*, with beautiful garden: a very popular pleasure resort. The fine suburb of *Schwabenberg*, where are many handsome villas. The prospect is exceedingly beautiful. Cog-railway reaches the summit in twenty minutes.

Seventh Day. By train from Pest to Stuhl Weissenburg. Here the ancient kings of Hungary were crowned. One of the most interesting cities in the country. It is embosomed in beautiful vineyards, amongst which delightful drives may be indulged in. The old *Episcopal Palace* and the *Cathedral* are the most conspicuous buildings. The town has large calico-printing works, and does a great trade in fruit and wine. Here native life may be seen in its typical characteristics.

Eighth Day. Excursion to Lake Balaton, called by the Germans the Plattensee, Hungary's largest lake. It abounds in fine fish, and is surrounded by volcanic hills and beautiful vineyards. Steamer twice a day to Füred, where are famous carbonic acid baths. A crowded summer resort. Back to Pest.

Ninth Day. Start down the Danube for Orsova. A grand voyage of 36 hours through captivating scenery. The view for some hours below Buda-Pest is somewhat monotonous, as the river traverses the vast Hungarian wheat-growing plains. But all is changed after passing the influx of the Drave. The tourist sleeps a night on board the splendid steamer.

Tenth Day. Down the Danube. On the right bank are picturesque vine-clad hills, with many ruined castles. During the day, towards evening, Belgrade is reached, and those who wish to visit Servia disembark at this point, the capital of that country. The steamer reaches the famous Defile of Kasan, the grandest scene on the mighty river. Before reaching Orsova the celebrated inscription of Trajan is seen on the perpendicular cliffs.

Eleventh Day. Orsova is the last town in Hungary, touching the Roumanian frontier. It is the gateway to the valley of the Czerna, one of the loveliest districts in all Europe, in the foothills of the Lower Carpathians.

Twelfth Day. From Orsova, visit the *Baths of Hercules*. This Carpathian paradise is alone worth all the trouble and expense of the journey. It was the favourite summer resting-place of the unfortunate Empress, Queen Elizabeth. In the old Roman days it was a celebrated health resort. The sulphur baths are amongst the most powerful chalybeate springs known. The excursion from Orsova is through enchanting scenery on the Roumanian border.

Thirteenth Day. Railway to Buda-Pest. The long journey is through a varied and interesting country.

Fourteenth Day. From Buda-Pest to Vienna by rail.

Longer Tours. Those who wish to spend *three weeks* in the country can, by way of extension, enjoy an expedition into the Tatra, the lofty range of the West Carpathians. *A month* in Hungary affords an opportunity of excursions in the fine district between Agram and Fiume.

The fare from London to Buda-Pest is: First class, single, £9 14s. 8d.; return, £16 3s. 10d. Second class, single, £6 12s. 5d.; return, £11 1s. 4d.

Books. The literature of Hungarian travel is usually combined with descriptions of the whole Austro-Hungarian Empire. Specially interesting are Dowie's "Girl in the Carpathians," Gerard's "Land Beyond the Forest," Pennell's "To Gipsy-Land," an anonymous work in two volumes, entitled "Magyarland," and Cross's "Round about the Carpathians."

Continued

PRACTICAL GEOMETRY

Areas Preliminary Principles of Plane Figure Areas. Construction of Areas Equal to or Proportional to Others. Proportional Division of Areas

Group 8
DRAWING
9

Continued from page 1088

By WILLIAM R. COPE

Principles Concerning Areas of Plane Figures. In order to understand more thoroughly the following principles, it would be well for beginners to go through Euclid's demonstrations of them. It should also be remembered that the boundary line, or *perimeter*, of any closed figure encloses an amount of surface called its *area*.

1. *Parallelograms* upon the same base, or upon equal bases, and between the same parallels, are equal [Euc. I. 35 and 36]. Thus $ABCD = ABDE$ [**320**], or $ABCD = ABFE$ [**321**], or $ABCD = EFHG$ [**322**].

2. *Triangles* upon the same base, or upon equal bases, and between the same parallels, are equal [Euc. I. 37 and 38]. Thus, $ABC = DBC$ [**323**], or $ABC = DEF$ [**324**].

3. If a parallelogram and a triangle be upon the same base, and between the same parallels, the parallelogram shall be double of the triangle [Euc. I. 41]. Thus, $ABCD =$ twice ABC [**325**], or $ABCD =$ twice EBC [**326**].

4. The square on the hypotenuse of a right-angled triangle is equal to the sum of the squares on the other two sides [Euc. I. 47]. This fact was discovered by Pythagoras, 580 B.C.

Thus, the square $ABCD =$ square $EGFB +$ square $AEHJ$ [**327**].

NOTE. This is true of other figures constructed upon the sides of a right-angled triangle, as long as they are similar. Thus, the hexagon $ABKLMN =$ hexagon $BEOPQR +$ hexagon $AESTUV$ [**327**].

5. *Parallelograms* and *triangles* upon the same base have their areas in the same ratio as their altitude. Thus, $ABEF =$ twice $ABCD$ [**328**], or $ABD =$ four times ABC [**329**].

6. Parallelograms and triangles *of the same altitude* are to one another as their bases [Euc. VI. 1]. Thus, $ABCD = \frac{2}{3} BEFG$ [**330**], or $ABC =$ three times ABE [**331**].

7. The area of a rectangle is equal to that of a triangle upon the same base, but having twice the altitude. Thus, $ABCD = ABE$ [**332**].

8. The areas of circles are proportional to the squares on their diameters. Thus, the circle $ABC =$ four times DEF [**333**].

Construction of Areas Equal to or Proportional to Others.

334. TO DRAW AN ISOSCELES TRIANGLE WHOSE AREA SHALL BE HALF THAT OF THE GIVEN RECTANGLE $ABCD$. Bisect AB by the perpendicular FE, cutting CD in E. Join AE and BE, and AEB is the required triangle.

335. TO CONSTRUCT A RECTANGLE EQUAL IN AREA TO THE GIVEN TRIANGLE ABC. At A and B erect AE and BF perpendiculars to AB. From C draw CD perpendicular to AB (or AB produced), and cutting it in D. Bisect CD in G, and draw EGF parallel to AB and cutting AE in E and BF in F. Then $ABFE$ is the rectangle required.

NOTE. The rectangle $AHJK$ shows that the area of a triangle may also be expressed as the altitude multiplied by half the base.

336. TO CONSTRUCT A RECTANGLE EQUAL IN AREA TO THE GIVEN RECTANGLE $ABCD$, AND ONE SIDE TO BE EQUAL TO GH. Then the other side of the required rectangle must be a fourth proportional to AB, GH, and AD. Set off along AB from A, the given side AE equal to GH. Join E and D, and through B draw BF parallel to ED, cutting AD produced in F. Through F draw FG parallel to AB, and through E draw EG parallel to AF. Then $AEGF$ is the required rectangle.

337. TO CONSTRUCT A TRIANGLE OF A GIVEN HEIGHT DE, AND EQUAL IN AREA TO THE GIVEN TRIANGLE ABC. Through A draw FG perpendicular to BC and equal to the given height DE. Join FB and FC, and through A draw AJ and AH parallel to FB and FC respectively, cutting BC in J and H. Join FJ and FH, then FJH is the triangle required.

338. TO CONSTRUCT AN ISOSCELES TRIANGLE EQUAL IN AREA TO THE GIVEN TRIANGLE ABC, AND WITH ONE OF ITS ANGLES EQUAL TO ONE OF THOSE IN THE TRIANGLE ABC. Find the mean proportional BF to BA and BC. With centre B and radius BF describe an arc cutting BA produced in G and BC in H. Join G and H, then GBH is the required triangle.

339. ON A BASE EQUAL TO DE TO DESCRIBE A TRIANGLE EQUAL IN AREA TO THE GIVEN TRIANGLE ABC. On BC, or BC produced, set off BF equal to DE. Draw AF, and from C draw CG parallel to AF. Join G and F. Then GBF is the triangle required.

340. TO TONSTRUCT AN EQUILATERAL TRIANGLE EQUAL IN AREA TO ANY GIVEN TRIANGLE ABK. Through K draw KC parallel to the base AB. Bisect AB by the perpendicular EC cutting KC in C. Join CA and CB, thus obtaining an isosceles triangle, CAB, equal in area to ABK. Upon AB describe the equilateral triangle ABD. Now find the mean proportional EF to the altitudes ED and EC of the two triangles ABD and ABC. With E as centre, and radius EF, describe an arc cutting EC in G. Through G draw GH and GJ parallel to DA and DB respectively, and cutting AB produced in H and J. Then GHJ is the required triangle.

341. TO CONSTRUCT A RECTANGLE WITH SIDES IN THE RATIO OF 3 TO 4, AND AN AREA EQUAL TO THE SQUARE ON AB. Draw any straight line CD, divided in the ratio 3 to 4 at E. Find a mean proportional EF to CE and ED. Produce EF to G, making EG equal to AB. Draw GJ and GH

parallel to *FC* and *FD* respectively, cutting *CD* produced in *J* and *H*. Construct the required rectangle with sides equal to *EJ* and *EH*, as shown.

342. To Construct a Square Equal in Area to a Given Triangle *ABC*. On the base *BC* make a rectangle *BCDE* equal to the triangle *ABC*. Find a mean proportional *CG* to *BC* and *CD*. Then *CG* is one side of the required square.

343. To Construct a Rectangle Equal in Area to a Given Circle *ABC* (approximate). Draw any radius *DB* for a short side of the rectangle. Divide *DB* into 7 equal parts. Draw *BE* perpendicular to *DB*, and equal to 3¼ times *DB*. Complete the rectangle *DBEF* as shown.

344. To Construct a Parallelogram Equal in Area to a Given Trapezoid *ABCD*. Join two opposite corners, *D* and *B*, and through *C* draw *CE* parallel to *DB*, cutting *AB* produced in *E*. Bisect *AE* in *F*. From *F* draw *FG* parallel to *AD*, cutting *DC* produced in *G*. Then *AFGD* is the required parallelogram.

345. To Construct a Parallelogram Equal in Area and Perimeter to the Given Triangle *ABC*. Produce either side, say *BC*, to *D*, making *CD* equal to *CA*. Bisect *AB* in *E*, and *BD* in *F*. Through *C* draw *CH* parallel to *BA*. With *B* as centre, and radius *BF*, describe an arc cutting *CH* in *G*. Join *BG*, and through *E* draw *EH* parallel to *BG*. Then *EBGH* is the required parallelogram.

346. To Draw a Triangle of a Given Shape *ABC* and Area Equal to, say, 3 sq. in. From *A* draw a perpendicular *AD* to *BC*, and bisect it in *E*. Make the rectangle *BCFG* equal in area to the triangle *ABC*. With *B* as centre, and radius *BG*, describe the arc *GH*, cutting *CB* produced in *H*. Find *BJ* the mean proportional to *CB* and *BH*. Along *BJ*, or *BJ* produced, set off *BK* equal to $\sqrt{3}$ (the mean proportion of 3 and 1). Join *JA*, and from *K* draw *KL* parallel to *JA*, and cutting *AB* in *L*. Through *L* draw *LM* parallel to *AC*. Then *LBM* is the required triangle.

347. To Construct an Isosceles Triangle Equal in Area to a Given Trapezium *ABCD*, with One Side *AB* Common to Both Figures. Join *AC*, and from *D* draw *DE* parallel to *AC*, and cutting *BC* produced in *E*. Join *AE*. Then the triangle *ABE* is equal to the trapezium. Bisect *AB* by the perpendicular *FG*, and through *E* draw *EG* parallel to *AB*, and cutting *FG* in *G*. Draw *GA* and *GB*. Then *ABG* is the required triangle.

348. To Construct any Figure Similar to a Given One *ABCDE*, and Having its Area in any Proportion to it, say, 3 : 1. Let *AB* be the one equal part, and make *AF* equal to 3 times *AB*. Find a mean proportional *AG* to *AB* and *AF*. Then *AG* is the base of the required figure to be completed as shown.

349. To Describe a Circle Equal in Area to the Difference of Two Others. Let *AB* be the diameter of one given circle, and upon *AB* describe the circle. With *A* as centre, and *AC* (the diameter of the other given circle) as radius, cut the first circle in *C*. Join *AC* and upon it describe the second given circle. Join *CB* and upon *CB* describe the required circle.

350. To Construct a Figure Similar to a Given One *ABC*, but Half its Area. On *BC* describe a semicircle, and bisect it by *DE*. Draw *BE* and make *BF* equal to it. Through *F* draw *FG* parallel to *CA*. *GBF* is the required figure.

351. To Describe a Circle Equal in Area to the Sum of Two Others. Draw *AC* and *CB* (the diameters of the given circles) perpendicular to each other, and describe the given circles upon *AC* and *CB*. Join *AB*, which is the diameter of the required circle.

352. To Make a Square whose Area shall be Equal to 5 sq. in. Draw a line *AC*, 1 in. long, and perpendicular to it *CB*, 2 in. long. Join *AB*, which is equal to $\sqrt{5}$. Upon *AB* describe the required square *ABDE*.

353. To Make a Square Equal in Area to a Given Rectangle *ABCD*. Find a mean proportional *CF* to *BC* and *CD*. Upon *CF* describe the required square *CFGH*.

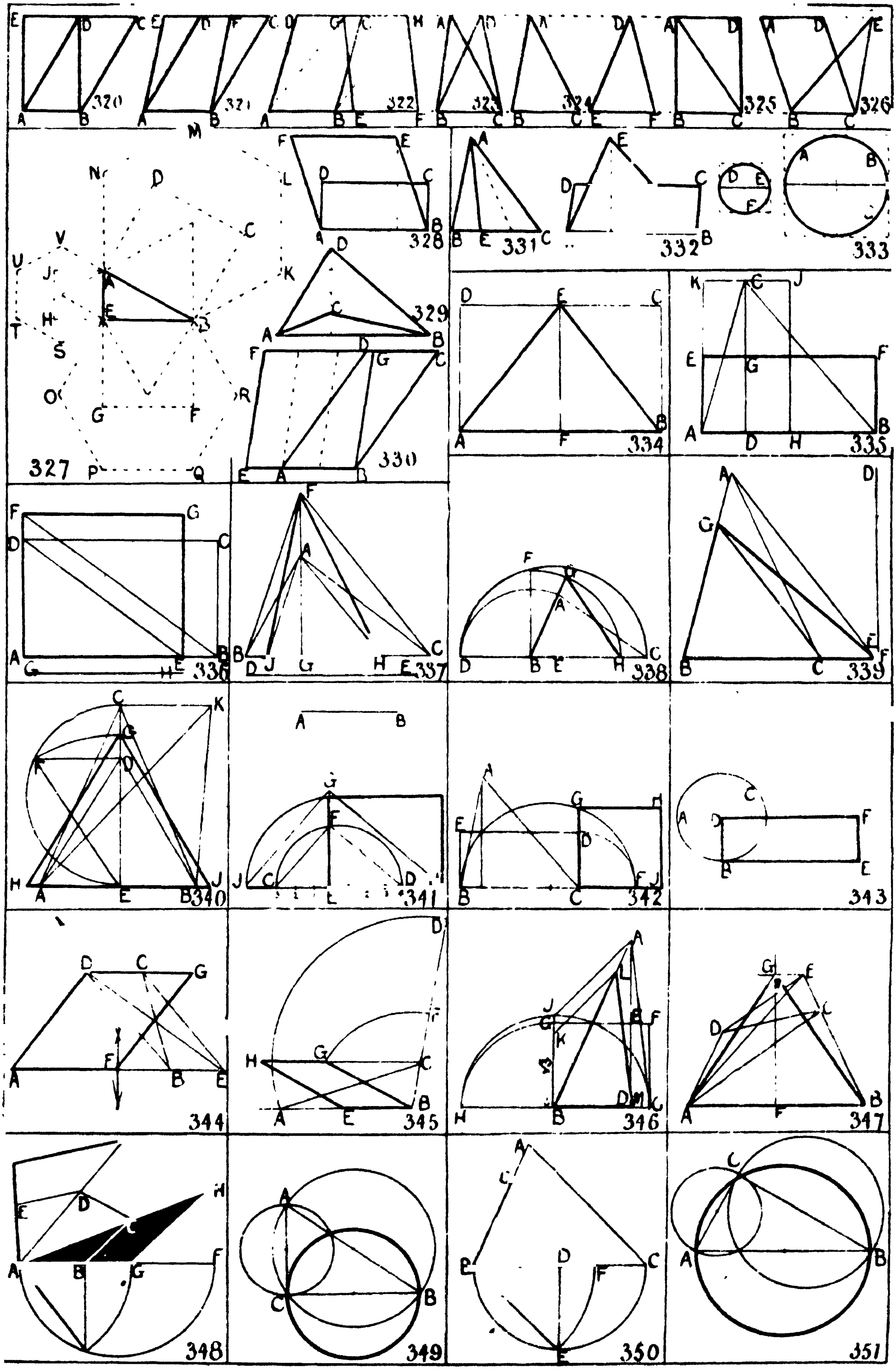
354. To Construct a Square whose Area shall be a Fractional Part (say ⅔) of that of a Given Square *ABCD*. Upon any straight line *EF* set off *EG* and *GF*, two and three convenient equal divisions. Upon *EF* describe a semicircle, and find *GH* the mean proportional to *EG* and *GF*. Join *HE* and *HF*. From *F* along *FH*, set off *FJ* equal to the length of the side of the given square. Through *J* draw *JK* parallel to *HE*. Upon *JK* describe the required square, as shown.

355. To Construct a Rectangle Equal in Area to a Given Square *ABCD*, and One Side of the Rectangle to be a Certain Length, as *EA*. Place the given side, *EA*, of the rectangle perpendicular to a side of the square, as *EA* and *AD*. Join *DE* and bisect it by the perpendicular through *F*, cutting *EA* in *G*. With *G* as centre, and *GE* or *GD* as radius, describe a semicircle, cutting *EA* produced in *H*. Then *AH* is the other side of the required rectangle, as shown.

356. To Reduce any Irregular Figure, as *ABCDE*, to a Triangle of Equal Area. Join *AC*, and through *B* draw *BF* parallel to *AC* and meeting *DC* produced in *F*. Join *AF*, and the triangle *AFC* equals the triangle *ABC* in area. Join *AD*, and through *E* draw *EG* parallel to *AD*, cutting *CD* in *G*. Join *AG*, and the triangle *AEG* equals (in area) the triangle *EGD*. Then *AFG* is the required triangle.

357. To Construct a Triangle Equal in Area to a Regular Polygon, as *ABCDEF*. Divide the polygon into equal triangles by lines drawn through the centre *G*, then *GCD* is ⅙ of the polygon. Make *HJ* twice the height of *HG*, and *KL* three times *CD*. Join *JK* and *JL*. Then *JKL* is one triangle equal in area to the polygon. Other triangles may be drawn equal in area.

358. In a Given Circle to Inscribe a Rectangle of a Given Area. Draw any diameter *BD*, and from the centre *E* draw *EF* perpendicular to *BD*, making *EF* such a length that *EF* × *ED* is one half the given area. Through *F* draw *AG* parallel to *BD* and cutting the circle in *A* and *G*. Join either of these points,



CONSTRUCTION OF AREAS EQUAL TO AND PROPORTIONAL TO OTHERS say *A*, to *B* and *D*. Through *E* draw *AC*, cutting the circle in *C*. Join *BC* and *CD*. Then *ABCD* is the rectangle required.

359. To Construct a Triangle Equal in Area to the Sum of Two Given Triangles *ABC* and *CED*. Place them so that a side *CB* of one is in the same line as a side *CE* of the other, and a corner *C* adjacent with a corner *C* of the other. Join *BD*, and through *E* draw *EF* parallel to *BD* and cutting *CD* in *F*. Through *F* draw *FG* parallel to *CB* and cutting *AB* produced in *G*. Join *CG*, and *AGC* is the triangle.

Proportional Division of Areas.

360. To Bisect any Irregular Quadrilateral Figure *ABCD* by a Straight Line Drawn Through One of its Corners *C*. Draw the diagonals *AC* and *BD*. Bisect *BD* (the diagonal opposite the given point *C*) in *E*. Through *E* draw *EF* parallel to *AC*, cutting *AB* in *F*. Join *FC*, which bisects the figure.

361. To Bisect a Given Triangle *ABC* by a Line Parallel to One of its Sides. On either side, say *AC*, construct a semicircle, and at the centre *D* erect a perpendicular *DE* to *AC*. With *A* as centre and *AE* as radius describe an arc cutting *AC* in *F*. Through *F* draw *FG* parallel to *BC*. *FG* bisects the triangle *ABC*. The other construction shows how to divide the triangle into four equal parts.

362. To Bisect a Given Triangle *ABC* by a Line Perpendicular to One of its Sides, say *AB*. Bisect *AB* in *D*, and from *C* draw a perpendicular *CE* to *AB*, cutting it in *E*. Find *BF* the mean proportional to *BD* and *BE*. Set off *BG* equal to *BF*. From *G* draw a perpendicular *GH* to *AB*. *GH* bisects the triangle.

363. To Bisect a Triangle *ABC* by a Line Drawn Through a Given Point *D* in One of its Sides. Bisect *BC* in *E*, and join *AD*. Through *E* draw *EF* parallel to *AD*, cutting *AC* in *F*. Join *DF*, which bisects the triangle.

364. To Divide a Given Triangle *ABC* into Two Equal Parts by Lines Drawn Through any Given Point *D* within it. From the corner of the triangle nearest the point *D* draw a line *AE* bisecting the opposite side *BC* in *E*. Join *DE*, and through *A* draw *AF* parallel to *DE*, and cutting *BC* in *F*. Then the lines *DA* and *DF* bisect the triangle.

365. To Divide a Circle into any Number (say Three) of Parts Equal in Area and Perimeter. Draw a diameter *AB*, and divide it into the same number of equal parts as the circle is to be (three in this case). Describe semicircles on opposite sides as shown.

366. To Divide a Semicircle into any Number (say Three) of Equal Parts by Concentric Semicircles. Bisect the radius *DC* in *E*. With *E* as centre, and *EC* or *ED* as radius, describe a smaller semicircle. Divide *DC* into the same number of equal parts (in this case three) into which the given semicircle is to be divided, and erect the perpendiculars to *DC* from *F* and *G*, cutting the smaller semicircle in *H* and *J*. With *D* as centre, and *DH* and *DJ* as radii, describe the concentric semicircles which trisect the large given semicircle.

367. To Divide a Given Triangle *ABC* into any Number of Equal Parts (say Three). First, by Lines Drawn Through One of its Corners *A*. Divide *BC* (opposite *A*) into three equal parts in *D* and *E*. Join *AD* and *AE*, which trisect the given triangle.

368. The Same. But, Secondly, by Lines Drawn Through a Fixed Point *D* in One of the Sides. Divide *AB* (the side containing the given point *D*) into three equal parts in *E* and *F*. Join *D* to the opposite corner *C*, and draw *EG* and *FH* parallel to *DC*, cutting *AC* in *G* and *BC* in *H*. Join *DH* and *DG*, which trisect the given triangle.

369. The Same. But, Thirdly, by Lines Passing Through a Fixed Point *D* within the Given Triangle *ABC*. Divide one of the sides, say *BC*, into three equal parts in *E* and *F*. Join *AE* and *AF*. Also join *D* to *A* and *E*, and through *A* draw *AH* parallel to *DE*, cutting *BC* in *H*. Join *DH*, then *ABHD* is one of the required three equal parts. Next, join *D* to *F*, and through *A* draw *AG* parallel to *DF*, cutting *BC* produced in *G*. Join *DC*, and through *G* draw *GJ* parallel to *CD*, cutting *AC* in *J*. Join *DJ*, then *ADJ* and *DHCJ* are the other two required equal parts.

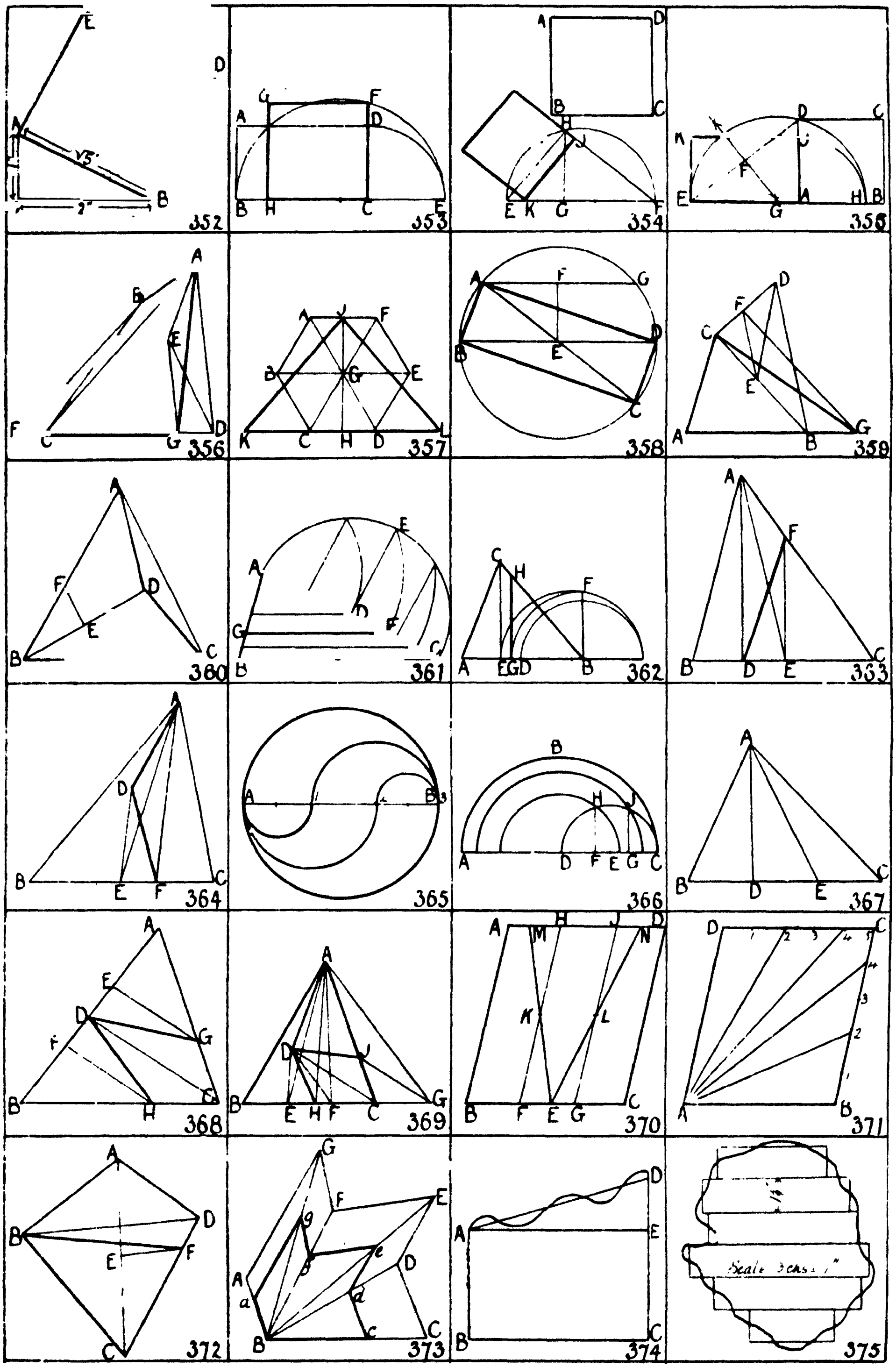
370. To Divide a Parallelogram *ABCD* into any Number of Equal Parts (say Three) by Lines Passing Through a Given Point *E* in One of the Sides. Divide *BC* into the required number (three) of equal parts in *F* and *G*. Draw *FH* and *GJ* parallel to *AB* or *CD*, and cutting *AD* in *H* and *J*. Bisect *FH* in *K*, and *GJ* in *L*. Through *K* and *L* draw *EM* and *EN*, cutting *AD* in *M* and *N* respectively. Then *EM* and *EN* trisect the given parallelogram.

371. To Divide a Given Parallelogram *ABCD* into any Number (say Five) of Equal Parts by Lines Drawn Through One of its Corners *A*. Divide each of two adjacent sides *DC* and *CB* into the same number (in this case five) of equal parts, into which the parallelogram is to be divided. Draw lines from *A* to 2 and 4 in *DC*, and to 2 and 4 in *BC*, and these lines divide the parallelogram into five equal parts. The same method may be used for dividing a square or oblong into equal or proportional parts.

372. To Bisect a Given Trapezium *ABCD* by a Line Drawn from One of its Corners *B*. Draw the diagonals *AC* and *BD*. Bisect *AC* in *E*, and draw *EF* parallel to *BD*, cutting *CD* in *F*. Join *BF*, which is the line of bisection.

Note. Problems 373—375 are explained in next lesson

Continued



CONSTRUCTION OF PROPORTIONAL AREAS. DIVISION AND REDUCTION

Continued from page 1169

STRENGTH AND METHODS OF TESTING

Stress and Strain. Strength of Timber. Stiffness. Resilience. Preparing Test Pieces. Testing Machine. Table of Timber Strength

By Professor HENRY ADAMS

Load, Stress, and Strain. The previous articles have dealt with the origin and general characteristics of the more commonly used materials, and the special property of resistance to stress and some other physical qualities will now be considered. Any load, however it may be applied to a body, induces a resistance which is called *stress*, and the alteration in form which is produced is called *strain*. There is, therefore, no load without stress, and no stress without strain. This will perhaps be more fully apprehended if the statement be amplified as follows: "By a load on any piece or member of a structure is meant the aggregate of all the external forces acting upon it, including the weight of the piece itself and of other pieces supported by it. By a strain is meant the change of form produced in a piece by the action of a load; and by a stress is meant the resistance set up in the material by its molecular forces opposing the action of a load in producing a strain. Thus a *load* of so many *pounds* upon a piece having so many *square inches area* produces a *stress* of so many *pounds per square inch*, the result being a *strain*, or change of form, of a certain amount, whether temporary or permanent, and, when large enough, appearing as stretching, shortening, bending, crumpling or twisting." The *strength* of a piece is measured by its power of resisting stress. The three chief kinds of stress are *tension*—stretching, pulling or tearing; *compression*—crushing, pushing or squeezing; *shearing*—cutting, nipping or sliding (called also *detrusion* when acting along the grain of wood). There are three other varieties, *transverse stress*—cross strain, bending, deflection, which is made up of tension and compression on opposite sides; *torsion*—twisting or wrenching, which is a variety of shearing; *buckling*—crumpling, corrugating, twisting, which merges into crushing when the length is short enough.

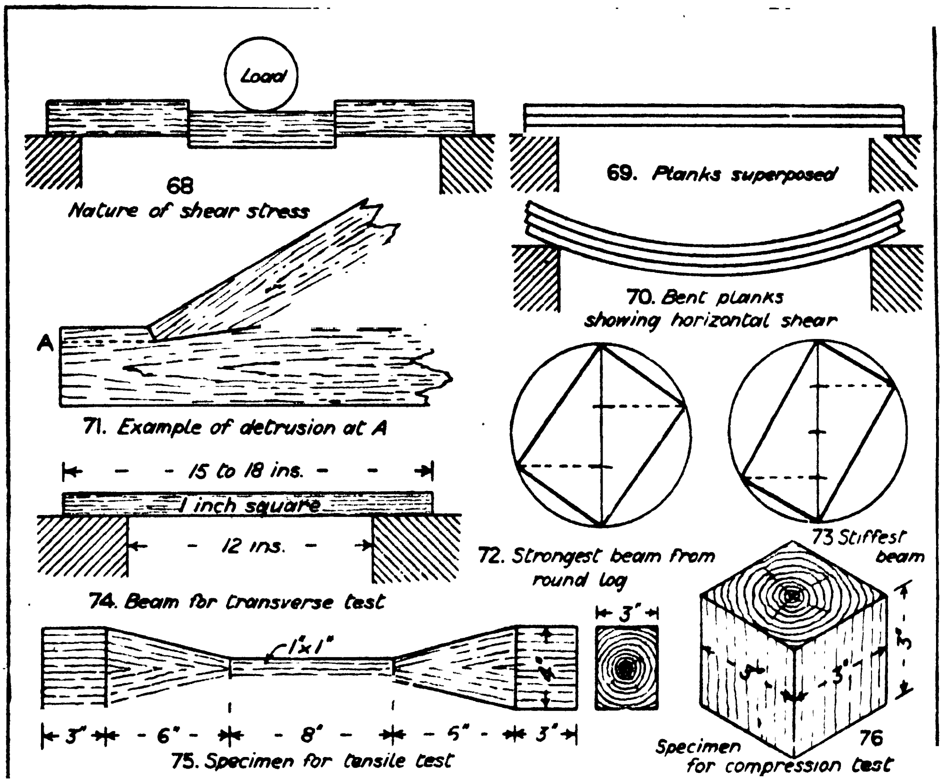
Tables of strength are available for a great variety of materials, the pieces being generally selected with the utmost care and every precaution taken to produce a high result. Applied to everyday practice these results give a false idea of the margin of safety between the working stress and the ultimate stress. When a factor of safety of, say, four is nominally allowed, the actual margin is seldom greater than two, and often less. Besides what may be called stress tests, there are ocular and other tests of quality, depending upon the nature of the material and the use to which it is proposed to be put.

Tension. The word tension is used to express the state or condition of a body when any forces acting upon it tend to pull any two portions asunder; it is then said to be in tension, or under tension. When either the stress or strain are referred to, the terms *tensile stress* and *tensile strain*, or *extension*, are used. The tensile strength of a piece is its ability to resist being pulled in two, and is measured by the pull in units of weight per unit of area necessary to cause rupture. When the material will break with moderate loads the units are generally pounds and square inches, but when heavy loads are required the units may be tons and square inches. In testing the majority of materials it is necessary to prepare the sample piece in a special form, varied with the kind of material, so that the fracture may take place within a certain limited distance near the centre, and so that the pull shall be in line with the axis of the piece. If the pull were not truly axial—*i.e.*, in the line passing through the centre of gravity of every transverse section—the stress caused would not be uniformly distributed, but would be greater on the side to which the line of pull was nearer, and less on the opposite side. The ultimate stress would thus be reached first on a small portion which would permit of rupture with a smaller total load, and this being divided over the sectional area would give a lower mean stress, and make the material appear to have less strength than it actually possesses. The ends of the pieces have also to be prepared in special shapes to suit the method of holding them while the force is applied, so as to avoid any interference with the reliability of the test. Although every means may be adopted to secure uniform results, it is very rare for any two samples of the same material, even when taken from the same piece and tested in the same machine by the same man, to give precisely the same figures, and therefore several samples should be tested before any average can be arrived at. It is also necessary to note the maximum and minimum results, the latter for use in calculations regarding the strength of structures, and the former in designing machines to overcome the strength, such, for instance, as punching and shearing machines.

Compression. This term expresses generally the opposite of tension, and hence we have *compressive stress* and *compressive strain*. The *compressive strength*, or resistance to crushing, is measured in the same units as before—viz., pounds per square inch or tons per square inch as the case may be. In compressive tests the pieces, whatever the material may be, are generally formed into simple cubes, or rectangular blocks, the size depending upon the material and the capacity of the machines. Fibrous, granular, and crystalline materials may crack before finally giving way, and other materials may bulge and flatten out with no particular point at which ultimate failure may be said to take place. When the length of a piece, between the points at which the force and resistance are applied, exceeds a certain limit according to the nature of the material, the result is not pure compression. There is, in addition, a tendency to bend, causing an increase in the compressive stress on one side and a reduction on the other. The ultimate strength in these cases is practically limited by the load at which incipient bending takes place, as a very small addition to the load will produce total failure. This load depends approximately upon the area of cross section compared with the length, or upon the area and the ratio between the length and least diameter or width, but more accurately upon the area and the ratio of the length to the least radius of gyration of the section. In other words, the disposition of the area of cross section as well as its magnitude must be taken into account, together with the length. The mode of finding the radius of gyration, moment of inertia, and modulus of section—all closely allied—will be explained further on.

Shearing. When a loaded beam is supported at the ends, there is a tendency to shear at every vertical section between the load and the supports—*i.e.*, to cut through a cross section at any point by the part next the load sliding downwards against the part next the support [68]. There is also a tendency to shear horizontally at any point in the depth. The latter may be illustrated by a number of planks laid one upon the other, the ends being supported [69], when an actual sliding will be seen to occur, even with their own weight [70]. Shearing stress also occurs when parts in tension are joined by rivets or bolts, the rivets or bolts tending to be cut across, called single shear when failure may occur by cutting through the section in one plane only, and double shear when the cutting must occur in two planes at the same time. This matter will be explained in greater detail under the head of STABILITY OF STRUCTURES.

Detrusion. A special case of shear stress occurs in timber when from the shape and position of the parts there is a tendency to push off a portion in the direction of the grain, as in the beam of a roof [71] where the foot of the principal rafter is stepped into it, and presses against it in such a manner as to cause a liability to push off the upper part along the dotted line. Failure is prevented by leaving sufficient length between the point of the principal rafter and the end of the tie-beam, the necessary amount varying with the kind of wood. Those woods that are very straight-grained and split easily require



DIAGRAMS RELATING TO STRENGTH OF TIMBER

more than those with an irregular or interlaced grain, particularly if the medullary rays in the latter are strongly marked.

Transverse Stress. A projecting beam fixed at one end and loaded at the other, or supported at both ends and loaded in the middle, or loaded and supported in any way that causes it to bend, is said to be under transverse stress, the fibres on the outside of the curve being in tension, and those on the inside of the curve in compression, while the intensity of each stress reduces towards the centre of the depth, or the centre of gravity of the section, at which point they both vanish. The layer where this occurs is called the *neutral layer*, and the same line in a cross section is called the *neutral axis* of the beam. There are also vertical and horizontal shearing stresses set up in the beam at the same time. The unit of transverse stress is called the *modulus of rupture*, and sometimes—rather indefinitely—the *strength modulus*. It is commonly supposed to be the same as the maximum fibre stress, but from various causes it is usually greater than this. It is eighteen times the load that, placed in the centre of a beam 1 in. square, and 1 ft. between the supports, will just suffice to break it.

Torsion. If a shaft or axle be supported, and one end fixed while an attempt be made to rotate it by a lever fixed on the other end, a *torsional stress* will be induced, and a *twist*, or *torsional strain*, will be caused. Line shafting in a machine-shop is always subject to torsion from the force applied to the driving pulley and the varying resistances due to the work done from the other pulleys. Torsion may be described as a *circular shear*. It does not occur to any marked extent in structural work, and then only as the result of bearing surfaces not being properly levelled.

Buckling. A deep web plate, or the top flange of a girder, or the flange of a stanchion under compression, tends to bend, or to yield, by taking a wavy form. This is frequently a very important matter, and apt to be overlooked. It occurs at a much lower stress than that due to the crushing of a short block of the same material, and requires special calculations, which will be dealt with later on.

Permanent Set. When a piece is put under stress, it changes shape—elongating, shortening, bulging, etc., which alteration may or may not disappear upon the removal of the exciting cause. Any change from the original dimensions that remains after the removal of the stress is called *permanent set*. There is no very precise limit, compared with the ultimate strength of the material, at which permanent set commences, but, approximately, it begins to be appreciable when the piece is loaded to half its ultimate capacity.

Elastic Limit. The *elastic limit*, or *limit of elasticity*, is the point up to which the change of length in a piece under test is sensibly proportional to the force applied, and from which the piece will return to its original dimensions when the force is removed. In other words, the elastic limit is the maximum stress per square inch sectional area which any material can undergo without receiving a visible permanent set. As the elastic limit is the highest stress that can be put upon any piece without causing actual damage to it, the *factor of safety* should be a ratio determined by the elastic limit rather than by the ultimate strength. Generally speaking, the working stress should not exceed half and the proof stress two-thirds of the elastic limit.

Modulus of Elasticity. The modulus of direct elasticity, or *stress-strain modulus*, known also by many other names, particularly that of *Young's modulus*, is the ratio obtained by experiment of the stress per unit of section to the strain per unit of length up to the limit of elasticity. It is fairly constant for each material within this limit, but beyond it the strain increases more rapidly than the stress. It was at first described as the height in feet to which a body would have to be piled in order that any small addition to its top, of its own substance, might compress the rest to an extent equal to the bulk of that added quantity. This is strictly Young's modulus, and is expressed in feet, but out of compliment to his memory his name is still associated with the present stress-strain modulus. An intermediate stage, which, however, is numerically equivalent to the present stress-strain modulus, was reached by Hooke, who defined the modulus of elasticity as the load which would increase a bar to twice its original length, assuming the elasticity to remain perfect so long.

The modulus of elasticity affects chiefly the extension of material under direct tensile stress, and shortening under direct compressive stress. It also affects the resistance to bending or deflection, which is made up of extension on one side and compression on the other. This modulus is used in calculations of the strength of struts where the maximum working or proof stress must be below the limit where a tendency to bend commences.

Fatigue of Materials. When repeatedly strained beyond their elastic limit, although well within their ultimate strength, certain materials, as wrought iron and mild steel, take an increasing permanent set, and ultimately break with a smaller load than a similar piece left in its original state, but if annealed before rupture takes place the elasticity will be renewed. This loss of strength, *being recoverable*, is termed *fatigue*. The number of repetitions in imposing the load without annealing that may take place before fracture depends upon the extent to which the elastic limit is surpassed. A similar fatigue is induced when alternations of stress take place, say, from tension to compression and vice versâ, although the elastic limit is not overpassed in either direction. The safe working stress has about the same extent of range in tons, whether the stress be varying in tension only, in compression only, or in tension and compression alternately, so that in the latter case with equal stresses in either direction each extreme would be only about half the maximum possible in either of the former cases.

Strength of Timber. The table on next page gives in a compact form a general view of the chief elements of the strength of timber and some other useful particulars.

The various figures given by published tables are included in the range of values shown, except where extreme differences from the general average showed a probability of error. The normal variations are chiefly caused by differences in the quality and the seasoning. The pieces are very carefully selected so as to be straight-grained and free from knots or other visible defects, and, unless otherwise stated, they are always tested in their seasoned state.

In testing the differences of strength between green or unseasoned timber and dry or seasoned timber, it appears that green timber has only about 80 per cent. of the initial strength of dry timber, but the former would shrink badly and decay rapidly. Too much seasoning, or desiccating, is apt to render some timber, as fir and pine, brittle ; other timber, as mahogany and beech, is rendered brittle by age.

Weight of Timber. The weight of most timber varies according to the part of the tree from which it is cut ; as a general rule, that cut from the top of a tree may be taken as about 3 to 5 per cent. lighter than that cut from the butt. The weight also varies according to whether the timber is green or seasoned ; generally the seasoning of wood reduces its weight by about 5 to 15 per cent.

The shrinkage of timber in width during the process of seasoning may be taken as about 2 to 5 per cent., while oak often shrinks as much as 8 per cent. The shrinkage of timber in length is so small that it is not worth considering.

Specific Gravity. Relative weight per unit of volume and specific gravity are interchangeable terms with some materials, such as iron; with other materials, such as wood, the specific gravity taken in the ordinary way would vary with the length of time the wood was immersed, but with such material as cement, the weight per unit of volume has no direct comparison with the specific gravity. In the first class of materials, and in the second if only a short time be allowed to elapse so that the material does not become soddened, the weight of a given volume, such as a cubic foot, will equal the product of the specific gravity into the weight of a cubic foot of pure water at standard temperature and pressure ; but in the third class the specific gravity of the mass as individual grains is taken, and the comparison just stated will not hold good. If a comparison of weight is required in this class, then the *relative density* must be taken. Relative density, sometimes called specific density, may be defined as the weight of a given volume or bulk compared with that of an equal volume of pure water.

77. COMBINED TRANSVERSE AND TENSILE TESTING MACHINE FOR TIMBER OR CAST IRON.

Stiffness of Timber. Stiffness is an important property of timber, and it may often be necessary to make a calculation of its resistance to bending rather than of its ultimate strength, as, for instance, in the case of fir joists to which a plaster ceiling is to be attached. The strongest beam that can be cut out of a circular log is shown in **72**, and the stiffest out of the same log is shown in **73**. In the former the diameter is divided into three equal parts and perpendiculars drawn as shown, while in the latter the diameter is divided into four equal parts. The proportion of depth to breadth in the strongest beam is $\sqrt{2}$ to 1, and in the stiffest $\sqrt{3}$ to 1. The actual strength and stiffness, of course, depend upon the particular timber.

Resilience of Timber. By resilience is meant the work performed in bending timber to its proof deflection, but some authors define it as the resistance to transverse impact ; others call it toughness.

STRENGTH OF TIMBER

Material.	Ultimate Strength in lb. per Square Inch.					Specific Gravity.	Weight per Cubic Foot.	Weight per Cubic Inch.	Modulus of Elasticity.
	Tension.	Compression.	Detrusion or Shear along Fibres.	Shear through Cross Section.	Modulus of Rupture				
							lb.	lb.	
Acacia	11,200 to 13,000	..	..	..	11,200	·7 to ·8	44 to 50	·025 to ·029	1,600,000
Alder	10,000 to 14,000	6,700	..	..	..	·75	47	·027	1,000,000
Ash	12,000 to 17,000	8,600 to 9,300	460 to 1,400	6,280	12,000 to 18,000	·7 to ·8	44 to 50	·025 to ·029	1,600,000
Beech	11,000 to 22,000	7,700 to 9,800	..	5,223	9,000 to 12,000	·7	44	·025	1,350,000
Birch	15,000	3,300 to 6,400	560 to 815	5,595	11,400 to 11,580	·71 to ·75	44 to 45	·025 to ·026	1,600,000
Box	20,000	10,300	..	..	14,670	1·28	80	·046	2,000,000
Cedar, American	8,000	6,000	..	1,500	4,600	·55	34	·02	500,000
„ Lebanon	11,000	5,800	..	..	7,800	·49	31	·018	486,000
„ West Indian	5,000	5,700	..	..	8,660	·75	47	·027	..
Chestnut	9,000 to 13,000	..	600 to 690	1,535	10,600	·56 to ·66	35 to 41	·02 to ·024	1,140,000
Cork	..	..	..	..	..	·24	15	·009	..
Deal, Christiania	12,000	5,850	..	..	9,370	·69	43	·025	1,672,000
Ebony	..	19,000	..	7,750	12,600	1·18	74	·043	..
Elder	10,000 to 15,000	7,450 to 9,970	..	..	..	·73	45	·026	..
Elm, Canadian	9,200	9,200	..	..	14,490	·75	47	·027	2,470,000
„ English	4,480 to 14,000	5,600 to 10,300	1,400	..	4,700 to 9,700	·55 to ·59	34 to 36	·02 to ·021	700,000 to 1,340,000
Fir, Baltic	8,360 to 12,000	2,500 to 5,500	500 to 1,500	..	4,900 to 10,000	·48 to ·71	30 to 44	·017 to ·025	700,000 to 2,000,000
„ Spruce	2,900 to 12,000	5,000 to 6,800	117 to 470	3,255	9,000 to 12,300	·46 to ·51	29 to 32	·017 to ·018	1,400,000 to 1,800,000
Greenheart	8,000 to 9,200	12,000 to 15,200	..	..	16,500 to 27,500	·93 to 1·15	58 to 72	·034 to ·042	1,200,000 to 1,700,000
Hazel	18,000	..	..	..	..	·86	54	·031	..
Hornbeam	15,000 to 20,000	4,600 to 8,500	..	..	..	·75	47	·027	1,543,000
Ironwood	16,000	9,900	..	..	18,000	1·04 to 1·14	65 to 71	·038 to ·041	1,950,000 to 2,100,000
Jackwood	..	..	..	..	10,980	·67	42	·024	1,810,000
Kauri or Cowrie	9,600 to 10,900	..	..	..	9,600 to 11,000	·56 to ·64	35 to 40	·02 to ·023	1,982,400
Larch	4,000 to 11,000	3,200 to 5,500	900 to 1,600	..	5,000 to 10,000	·53 to ·55	33 to 34	·019 to ·02	905,000 to 1,300,000
Lignum vitæ	11,800	10,000	..	..	20,600	1·33	83	·048	..
Lime	..	..	..	..	..	·56	35	·02	..
Mahogany, Honduras	3,000 to 18,000	6,000 to 8,000	..	..	11,500 to 12,600	·56 to ·67	35 to 42	·02 to ·024	1,580,000 to 1,970,000
„ Spanish	3,400 to 16,300	6,700 to 8,200	..	..	7,600 to 7,800	·85	53	·031	1,255,000 to 3,000,000
Maple	10,600 to 15,400	6,000	300 to 640	6,355	10,160	·67 to ·75	42 to 47	·024 to ·027	1,452,000
Oak, African	14,400	9,320	..	..	15,100	·99	62	·036	2,283,000
„ American	6,720 to 12,000	6,000 to 6,900	725 to 1,000	4,000	10,000 to 12,600	·8 to ·96	50 to 60	·029 to ·035	2,000,000
„ English	6,000 to 19,000	6,400 to 10,000	700 to 2,300	4,000	9,600 to 13,600	·77 to ·93	48 to 58	·028 to ·034	1,200,000 to 1,750,000
Pine, red	2,700 to 14,000	4,700 to 7,500	500	..	7,000 to 10,300	·55 to ·66	34 to 41	·02 to ·024	1,460,000 to 2,350,000
„ white	3,360 to 11,800	4,100 to 5,000	270 to 480	2,000	7,400	·43 to ·55	27 to 34	·016 to ·02	1,570,000
„ yellow	2,000 to 12,000	4,000 to 8,000	150 to 415	4,000 to 5,000	7,100 to 8,450	·51	32	·018	1,600,000 to 2,480,000
„ Dantzic	3,100 to 10,000	5,400 to 6,900	..	..	8,550 to 13,800	·59 to ·64	36 to 40	·021 to ·023	2,300,000
„ Memel	9,400 to 11,000	6,500 to 13,440	540	..	8,000	·55 to ·59	34 to 37	·02 to ·021	1,536,000 to 1,957,000
„ Pitch	4,700 to 12,000	4,700 to 6,800	..	..	14,090	·64 to ·93	40 to 58	·023 to ·034	1,224,000 to 3,000,000
„ Riga	4,000 to 14,000	4,700 to 5,300	..	..	8,300 to 9,450	·46 to ·74	29 to 46	·017 to ·027	870,000 to 3,000,000
Plane	12,000	..	..	..	..	·64	40	·023	1,343,000
Poplar	4,600 to 7,200	3,100 to 5,100	..	4,418	9,600 to 10,200	·37 to ·42	23 to 26	·013 to ·015	763,000 to 1,130,000
Satinwood	..	..	..	..	19,200	·96	60	·035	..
Sycamore	9,600 to 13,000	6,900	..	..	9,600	·59 to ·69	36 to 43	·021 to ·025	1,040,000
Teak	3,300 to 15,000	8,500 to 12,000	..	..	12,000 to 19,000	·66 to ·98	41 to 61	·024 to ·035	1,943,000 to 2,414,000
Walnut	7,600 to 8,130	6,000 to 7,200	..	2,830	..	·71	44	·025	306,000 to 837,000
Willow	12,500 to 14,000	3,000 to 6,000	..	..	6,600	·38 to ·56	24 to 35	·014 to ·02	..
Yew	8,000	..	..	..	..	·79	49	·028	..

The next table gives a comparative view of some of the more important timbers as regards their strength, stiffness, and resilience.

Name of Wood.	Oak being = 100.		
	Strength.	Stiffness.	Resilience.
Acacia	95	98	92
Alder	80	63	101
Ash (English) ..	119	89	160
,, (Canadian) ..	79	77	—
Beech	103	77	138
Cedar (Lebanon) ..	62	28	106
Chestnut	68 to 89	54 to67	85 to 118
Deal (Christiania)	104	104	104
Elm (Canadian) ..	114	139	—
,, (English ..	82	78	86
Fir (spruce)	70 to 86	72 to 81	60 to 102
Greenheart	165	98	—
Hornbeam	108	—	—
Jarrah	85	67	—
Kauri, or Cowrie ..	89 to 92	116 to 162	74
Larch	103	79	134
Mahogany (Honduras)	96	93	99
,, (Spanish)	67	73	61
Oak (African) ..	144	101	138
,, (American) .	86	114	64
,, (Dantzic) ..	107	117	99
,, (English) ..	100	100	100
,, (Riga)	108	93	125
Pine (red)	81	132	—
,, (white) ..	99	95	103
,, (yellow) ..	66	139	—
,, (Dantzic) ..	108	130	—
,, (Memel) ..	80	114	56
,, (pitch) ..	82	73	92
,, (Riga)	80 to 83	62 to 98	64
Plane	92	78	108
Poon (Burmah) ..	104	99	82
Poplar	50 to 86	44 to 66	57 to 112
Sycamore	81	59	111
Teak	109	126	94
Walnut	74	49	111

COMPARISON OF VARIOUS TIMBERS

Test Pieces. The most usual test of timber is for transverse strength. Pieces are prepared, as in **74**, 1 in. square and 15 to 18 in. long, placed upon hard and firm supports 12 in. apart and loaded in the centre, or what is called loaded in the centre, which may be anything from a sharp V-edge to a round pin 3 in. diameter or a flat bar 1 in. wide. The variation in results is sometimes due to loose ideas as to what constitutes a central load. When larger test pieces than 1 in. square are used, such as 2 in. by 1 in., or 3 in. by 2 in., the deeper side is placed vertical, and the clear span is increased so that the load required to break them shall not be excessive.

The reduction to the standard value of 1 in. square and 1 ft. span is made by considering that the strength varies as $\frac{bd^2}{L}$ where b = breadth in inches, d = depth in inches, and L = span in feet. For tensile tests the pieces are shaped as in **75**, but may be larger, according to the capacity of the machine, frequently up to, say, 3 in. by 3 in. in the central part. The ends are held by cast-iron clips bolted together, and the taper is such that sufficient length shall be left to provide against detrusion without any sudden change in sectional area, which would at once form a weak spot.

For compression tests it is usual to take a cube of 2 or 3 in. side, as **76**, and press on the end grain, noting when splitting first occurs and when final crushing takes place. When the test piece is longer than its least width there is a reduction of strength, but it is not noticeable until the length exceeds about six times the least width. There are very few recorded tests of the resistance of timber across the grain, although it is a very important matter, frequently recurring in construction. For instance, when a timber beam rests on a post, the post will have a much greater working pressure per square inch of bearing area than will the beam, especially in fir, and it is necessary to spread the pressure on the beam by a hard wood corbel, in order to secure economy and efficiency; but it is mostly guesswork. Approximately timber will only bear half the load perpendicular to the grain that it will bear in the direction of the grain.

Testing Machines. Messrs. W. & T. Avery, Ltd., make a very compact and handy testing machine for transverse tests up to 40 cwt. and tensile tests up to 60 cwt. [**77**]. It may be used for ascertaining the transverse breaking strength and deflection of any material up to cast-iron bars 2 in. by 1 in. in section and 36 in. clear span, and in tension up to cast-iron specimens ½ in diameter. The bed plate is of cast iron, fitted with dogs for holding the specimens adjustable to suit different lengths of bars, the base being graduated so that the specimens may be accurately positioned, either 12 in, 24 in., or 36 in. between centres. A graduated deflection scale is attached to the machine, by means of which the varying deflections of a specimen under different strains can be ascertained at any period of the test. The scale has two series of graduations, one decimally by $\frac{1}{10}$th in. divisions up to 1 in., and the other by $\frac{1}{16}$ divisions up to 1 in. A cast-iron standard is bolted to the base plate, fitted with hardened steel bearing blocks upon which the fulcra knife-edges of the steelyard rest. It has a strong wrought-iron steelyard, machined and polished bright, fitted with hardened steel knife-edges, and graduated up to the full capacity of the machine, thus dispensing entirely with loose weights. The steelyard is provided with a sliding poise, by means of which the steelyard is kept in equilibrium and the strain indicated. To ensure the strain being steadily and evenly applied, and the most accurate results attained, a small hand-wheel is fitted to the poise for propelling the latter. The strain is applied by actuating a turned and polished hand-wheel, with a screw working through a steeled and hardened stirrup, which exerts the strain on to the specimen. To minimise the shock on the steelyard due to the breaking of the specimen, a spring buffer is fitted to the steelyard carrier. For tensile and compressive tests of wrought iron and steel, larger machines are generally used, which will be described in connection with the testing of metals.

Continued

Group 21
MATHEMATICS
9

Continued from page 1131

STOCKS AND SHARES

Capital. Dividends. Consols. Preference and Debenture Stocks. Brokerage. Stock-Jobbing. Problems. Powers and Roots

By HERBERT J. ALLPORT, M.A.

182. The cash necessary to carry on a business is called its *Capital*.

In some businesses, such as railways, waterworks, gasworks, etc., the capital required is too large to be supplied by one person. Let us suppose a new railway is to be made. The originators, or *Promoters*, of the scheme, issue a *Prospectus* explaining it, and stating the Capital required. This capital is divided into *Shares* of some fixed amount, such as £100, £20, £1, and members of the general public are asked to *apply* for shares. If enough applications are received to enable the promoters to go on with the undertaking, they *allot* shares to the applicants, and thus obtain the capital required. The persons who hold the shares are called the *Company*. The profits of the company in each year are divided among the shareholders in proportion to the face value of their shares. The money thus divided is called the *Dividend*.

A shareholder who wishes to retire from the company cannot obtain from it the money which he subscribed, but he may sell his shares. The amount he obtains for them will probably not be the same as the amount he originally subscribed: it will depend chiefly on the profits which the company makes.

183. The capital of a company is often called *Stock*. When the capital is called *stock*, a shareholder may sell *any quantity*, excluding fractions of a penny. For instance, a person holding £100 stock, may, if he pleases, sell £42 4s. 6d. stock.

But, if the capital is called *shares* he may only sell a complete number of shares. He cannot sell *part* of a share.

184. It is of the greatest importance the student should understand that "£100 stock" means "that amount of stock for which £100 was originally subscribed." It does *not* mean "that amount of stock which will *sell* for £100."

If £100 stock will sell for £100 cash, it is said to be *at par*. If it sells for *more* than £100 cash, say £108, it is said to be *at a premium of 8 per cent.*, or 8 *above par*. If it sells for *less* than £100 cash, say £97, it is said to be *at a discount of* 3 *per cent.*, or 3 *below par*.

185. In the case of public companies, we have seen that the dividend varies with the profits of the company. There is another sort of stock in which the dividend obtained from £100 stock is always the same. The Government of a country borrows money, for war expenses, and other purposes. The corporations of towns borrow money. Public companies borrow. In all these cases, a fixed interest is paid per annum on each £100 stock. A great portion of the British National Debt consists of the "Consolidated Annuities," abbreviated into "Consols," so called, because they were formed by consolidating several debts, contracted under various conditions, into one stock.

When a company borrows money at a fixed rate, it is often arranged that the interest on this new stock shall be paid before any dividend is paid on the original stock. The new stock is called *Preference* stock, and the old is called *Ordinary*. *Debenture* stock also receives a dividend before ordinary stock.

186. Stocks and shares are usually bought and sold through an agent called a *Stockbroker*. The charge which a broker makes for his services is called *brokerage*. In the case of Government stocks the brokerage is usually "⅛ per cent.," *i.e.*, 2s. 6d. on each £100 stock. The broker acts as the agent between the buyer or seller and the *Stock-jobber*, who deals in stocks and shares.

As an example, consider the following: On Monday, November 20th, Consols were quoted as "88⅞ to 89." This means that the jobber is ready to buy £100 of Consols for £88⅞ or to sell £100 of Consols for £89. Suppose then, a person, A, wishes to dispose of £100 Consols. A goes to his broker. The broker seeks out a jobber, who pays £88⅞ for the stock. The broker deducts £⅛, and hands over the remaining £88¾ to A. Next, if another person, B, wishes to buy £100 Consols, he goes to *his* broker. B's broker then finds the jobber, who now receives £89 for the stock; but B pays £89⅛ for it, since the broker requires £⅛.

A's Broker receives £⅛ from A		B's Broker receives £⅛ from B
A	Jobber	B
Receives £88⅞ from jobber, and pays broker £⅛. Thus clears £88¾	Pays A £88⅞. Receives from B £89	Pays £89 to jobber and £⅛ to broker. Pays £89⅛ in all.

Hence, in examples where brokerage has to be reckoned, the brokerage is added to the price when stock is bought, and subtracted when stock is sold.

It will be noticed that the broker's profit is certain. The jobber's profit, of course, depends on the difference between the buying price and selling price. Moreover, the jobber does not always manage to sell stock immediately after buying it, as was assumed in the above illustration.

187. We shall now work out various examples in stocks and shares. All questions in stocks depend on the principles of Proportion. The student ought to find no difficulties if he remembers that:

(1) £ s. d. *in* a company is *Stock*.
(2) £ s. d. to be *sold out* is *Stock*.
(3) £ s. d. to be *invested* is *Cash*.
(4) Brokerage is not reckoned unless specially mentioned in the question.

Example 1. I invest £4653 in $2\frac{1}{2}$ per cent. Consols at 94. How much stock do I get, and what is my income?

Here, we are told that £94 will buy £100 stock, and we have to find how much stock £4653 will buy.

$$\therefore £94 : £4653 :: £100 \text{ stock} : \text{Required stock}.$$

$$\text{Required stock} = £\frac{100 \times 4653}{94} = \underline{£4950\ \textit{Ans.}}$$

Again, we know that £100 stock gives an income of $£2\frac{1}{2}$. We have to find what income £4950 stock will give.

$$\therefore £100 : £4950 :: £2\tfrac{1}{2} : \text{Income}.$$

$$\therefore \text{Income} = £\frac{4950 \times 5}{100 \times 2} = \underline{£123\ 15\text{s.}\ \textit{Ans.}}$$

Or, in finding the income, we may work with cash instead of stock. For we know that by investing £94 an income of $£2\frac{1}{2}$ is obtained, and we are required to find what income is obtained by investing £4653.

Example 2. If I invest in 6 per cent. stock at 140, what percentage do I get on my money?

We have to find what income £100 will produce, if £140 gives an income of £6.

Hence,

$$£140 : £100 :: £6 : \text{Required percentage}.$$

$$\therefore \text{Percentage} = \frac{600}{140} = \underline{4\tfrac{2}{7}\ \textit{Ans.}}$$

Example 3. Which is the better investment, 3 per cents. at 98, or $3\frac{1}{2}$ per cents. at 115?

We may either, as in Example 2, find the actual percentage in each case; or, we may proceed as follows:

In the first stock, an investment of £98 produces £3 income. By proportion, we find that the amount which must be invested to produce $£3\frac{1}{2}$ is

$$\frac{£98 \times 3\frac{1}{2}}{3} = \frac{343}{3} = £114\tfrac{1}{3}.$$

But the second stock requires an investment of a greater sum, viz., £115, to produce this income of $£3\frac{1}{2}$. Therefore, the 3 per cent. stock is the better investment.

Example 4. A man sells out £5,000 from the $2\frac{1}{2}$ per cent. Consols at $85\frac{1}{8}$ (brokerage $\frac{1}{8}$) and invests the proceeds in $6\frac{1}{2}$ per cent. railway shares at $165\frac{1}{2}$ (brokerage $\frac{1}{4}$). Find the change in his income.

His income from Consols $= 50 \times £2\frac{1}{2} = £125$.

He sells £100 Consols for $85\frac{1}{8} - \frac{1}{8}$, *i.e.*, £85.

Therefore, he sells £5,000 Consols for $50 \times £85$.

Next, to obtain $£6\frac{1}{2}$ income from railway shares, he has to invest $£(165\frac{1}{2} + \frac{1}{4})$, *i.e.*, $£165\frac{3}{4}$. We find, by proportion, what income he will get by investing $50 \times £85$.

Thus,

$$165\tfrac{3}{4} : 50 \times 85 :: £6\tfrac{1}{2} : \text{Income}.$$

Hence, his new income

$$= £\frac{6\frac{1}{2} \times 50 \times 85}{165\frac{3}{4}} = \frac{\cancel{13} \times 50 \times \overset{5}{\cancel{85}} \times \overset{2}{\cancel{4}}}{\cancel{2} \times \underset{\underset{3}{\cancel{51}}}{\cancel{663}}}$$

$$= £\frac{500}{3} = £166\ 13\text{s.}\ 4\text{d.}$$

Therefore, the new investment increases his income by £166 13s. 4d. − £125 = £41 13s. 4d. *Ans.*

Note, that in examples of this sort, it is not necessary to find *the amount of stock* he obtains by the new investment.

Example 5. A man invested his money in railway stock which yielded a dividend of $6\frac{1}{2}$ per cent. the first year, and he paid 1s. in the £ income-tax. The next year the dividend was 6 per cent., and the income-tax was 10d. His net income was thus reduced by £119. How much stock had he?

Income-tax at 1s. on $£6\frac{1}{2} = 6\frac{1}{2}$s.

∴ In the first year, each £100 stock gives a net income of £6 10s. − 6s. 6d. = £6 3s. 6d.

Income-tax at 10d. on £6 = 5s.

∴ In the second year, each £100 stock gives a net income of £6 − 5s. = £5 15s.

Hence, his income from each £100 stock is reduced by £6 3s. 6d. − £5 15s., or 8s. 6d.

But the total reduction is £119, and we find by proportion what amount of stock this represents.

Thus,

$$8\text{s. }6\text{d.} : £119 :: £100 \text{ stock} : \text{Required amount}.$$

Whence, amount of stock

$$£\frac{100 \times 119 \times 2 \times 20}{17} = \underline{£28000\ \textit{Ans.}}$$

Example 6. A man invests £22000, partly in 3 per cent. stock at 88, and partly in $4\frac{1}{2}$ per cent. stock at 110. He finds that on the whole he gets $3\frac{1}{2}$ per cent. for his money. How much is invested in the $4\frac{1}{2}$ per cents?

His income $= 220 \times £3\frac{1}{2} = £770$.

If all his money was invested in the 3 per cents. his income would be

$$£\frac{22000 \times 3}{88} = £750.$$

This is £20 less than his actual income.

The L.C.M. of 88 and 110 is 440. If £440 is invested in the 3 per cents. it gives an income of $5 \times £3 = £15$. If £440 is invested in the $4\frac{1}{2}$ per cents., it gives an income of $4 \times £4\frac{1}{2} = £18$. That is, by investing £440 in the $4\frac{1}{2}$ per cents. instead of in the 3 per cents., he increases his income by £18 − £15 = £3. We have only to find how much he must transfer to the $4\frac{1}{2}$ per cents. to increase his income by £20.

Thus,

$$3 : 20 :: £440 : \text{Required Ans.}$$

∴ Amount invested in $4\frac{1}{2}$ per cents.

$$= £\frac{440 \times 20}{3} = £\frac{8800}{3}$$

$$= \underline{£2933\ 6\text{s.}\ 8\text{d.}\ \textit{Ans.}}$$

NOTE. If we had been required to find the amount of *stock* in the 4½ per cents., we should simply have had to use £400 stock, instead of £440 cash, for the third term of the proportion.

EXAMPLES 17

1. How much must be invested in 4¾ per cent. stock at 102 to obtain an income of £380 ?

2. A man sells out £9400 of 2½ per cent. Consols at 90, and invests the proceeds in a 4 per cent. stock. He thus increases his income by £5. What was the price of the 4 per cents. ?

3. How much must be invested in 3½ per cent. stock at 115⅝ (brokerage ⅛) to give an income equal to that obtained from £5775 stock in 3 per cents. at 99 ?

4. A man invests in a 5 per cent. stock. After paying an income tax of 1s. in the £, he finds he gets 3¾ per cent. on his money. At what price did he buy the stock ?

5. A man invests half his capital in 3¾ per cent. stock at 90, and the rest in 4½ per cents. He obtains the same income from each investment. What is the price of the 4½ per cents. ?

6. By investing a certain sum in the 3½ per cents. at 98, my annual income is £15 more than if I had invested in 3 per cents. at 90. What sum did I invest ?

7. A person has £8225 in a 3½ per cent. stock. He sells out as much of it, at 102, as will produce £4131, and invests the proceeds in 5¼ per cents. at 119. Find the change in his income.

8. A man invests £2500, some of it in 3¼ per cents. at 103⅓, and the rest in 4 per cents. at 140. On the whole, he gets 3 per cent. interest on his money. How much of each stock does he buy ?

Answers to Arithmetic

EXAMPLES 16

1. £441 12s. 6d.

2. Interest = £980 – £875 = £105. Interest on £875 for 3 years at 1 per cent. = £26·25. ∴ Required rate = £105 ÷ £26¼ = 4 per cent.

3. Interest on £100 for 8 years at 4½ per cent. = £36. Hence, the proportion is £36 : £183 3s. : : £100 : Required sum. This gives £508 15s. *Ans.*

4. At 4 per cent., the interest on £100 will have amounted to £100 in 100 ÷ 4 = 25 years *Ans.*

5. £1691 4s. 10d.

6. See Art. **126**. Then, working in a similar way to Art. **125**, we get the required interest = £4 15s. 11·98d. = £4 16s.

7. £212 10s.

8. By method of Art. **128, Ex. 2**, the present worth is found to be £1250. Hence, the true discount is £1447 0s. 7½d. – £1250 = £197 0s. 7½d.

9. See Art **131**. Amount of bill = £816 13s. 4d.

10. Bill is due on August 7th. On March 14th it still has 17 + 30 + 31 + 30 + 31 + 7 = 146 days to run. Banker's discount is, therefore, the interest on £400 for ⅖ year at 5 per cent. = £8. The holder of the bill receives £400 – £8 = £392.

POWERS AND ROOTS

138. When a product consists of the same factor repeated any number of times it is called a *power* of that factor.

Thus,

7 × 7 is the *second power*, or the *square* of 7.

7 × 7 × 7 is the *third power*, or the *cube* of 7.

Similarly, by taking four, five, six, etc., factors, we obtain the fourth, fifth, sixth, etc., powers.

A power of a number is generally expressed by writing the number only once, and placing after it, above the line, a small figure to show how many factors are to be taken. The small figure is called an *index*.

Thus,

$$7^2 = 49\ ;\ \ 7^3 = 343\ ;\ \ 7^4 = 2401.$$

139. A number is called the *square root* of its square. Since $7^2 = 49$, the square root of 49 is 7.

The symbol $\sqrt{\ }$ is used to denote the square root. This symbol was originally the letter *r*, and stood for *radix*, the Latin word for *root*.

The "square root of 49" is written $\sqrt{49}$.

Again, a number is called the *cube root* of its cube. $7^3 = 343$. Therefore, the cube root of 343 is 7.

The "cube root of 343" is written $\sqrt[3]{343}$.

Similarly, a number is the *fourth root* of its fourth power, the *fifth root* of its fifth power, and so on.

A *perfect square* is a number whose square root is a whole number. A *perfect cube* is a number whose cube root is a whole number.

Continued

THE PROPERTIES OF MATTER

The "Fundamental" Properties—so called. Universal Motion. The Kinetic Theory of Gases. Molecular Forces. Surface Tension

Continued from page 1144

By Dr. C. W. SALEEBY

"Fundamental" Properties of Matter. In previous chapters we have already had to note the most striking of the *physical* differences which may obtain in the case of matter that is *chemically* one and the same in each case. There is no better instance than that of water, already mentioned. But there is a very large number of other physical properties of very great importance, and each of these must be briefly considered. Before considering them, however, we must note the existence of certain properties of matter to which some reference has already been made. In the first place, there is *extension*, or magnitude, or the property of occupying space; in the second place, there is the property of *inertia*. [See page 312.] Then, again, there is the property of *attraction* between every particle of matter and every other particle that we call *gravity*, and have considered at length. We have also referred to the property which is called *impenetrability*—a rather stupid and misleading name. It does not mean that your tea cannot penetrate into a lump of sugar, but simply that where the particles of sugar are the particles of tea cannot also be. This character of matter was also referred to in our second chapter, and we showed how difficult it is to be consistent in our ideas on this point when we come to compare them with the new theory of matter. Only a few years ago it was possible to say that impenetrability is a self-evident property of matter, just as it seems self-evident that matter is that which occupies space; yet both extension and impenetrability, as properties of matter, are now undergoing grave criticism. The last of this group of properties of matter is *divisibility*, a word which explains itself. Here, again, we find ourselves in difficulties to-day. The physicist, for instance, may take a portion of water, and in theory may go on dividing it and dividing it until he reaches certain ultimate particles, which are still particles of water, but which, if further divided, would cease to be water. It is just at the point when this further division is undertaken that the domain of physics ends and the domain of chemistry begins. For when these molecules of water are broken up we get new objects of study (oxygen and hydrogen) which differ from water, not merely in physical state, but in their chemical nature.

Ultimate Divisibility of Matter. But we cannot run away from our difficulties in this fashion. As physicists we propose to study the properties of matter in general, and we assert that divisibility is such a property. Someone submits to us, let us say, a specimen of pure hydrogen; in theory we divide it and divide it until we reach its ultimate molecules, each of which consists of two atoms of hydrogen. [See CHEMISTRY.] Therefore, in theory, we divide the molecules into atoms, the smallest particles of matter, as we know it, that can exist. But in imagination we can conceive of the possibility of dividing even an atom; and, indeed, we now know that the atom is really a compound body made up of a number of electrons. It is believed that these electrons are absolutely the units of matter. But we have asserted that divisibility is a property of matter, are we not then entitled to declare that even electrons can be divided? However small we conceive an electron to be, yet it really has a material existence; we cannot conceive that a sufficiently delicate knife might not chop it in half; yet, as we already noted [page 313], it is more than doubtful whether the existence of the electron is a material existence at all; it is in all probability an electrical existence. In the last resort, therefore, we are compelled to abandon the assertion which has been so long maintained—that divisibility is a fundamental property of matter. We have not really added to our difficulties, however, but have simplified them. On the old view that divisibility is an essential property of matter, we were landed in alternate absurdities. On the one hand, we could not conceive of any particle of matter so small that it could not be divided, and yet if we imagined the process of division to go on for ever and ever we found ourselves in a difficulty just as great.

A Conundrum Solved. But it seems to the present writer quite clear that the new theory of matter has disposed of this old conundrum which has puzzled men's minds for centuries. It is true that matter, as we know it, has the property of divisibility, but when we reduce matter to its ultimate units we find that all our ordinary ideas are inapplicable. These ultimate units are found not to have any material existence at all, but to be manifestations of energy. Now, it is meaningless to talk of energy occupying space; it is meaningless to talk of energy being impenetrable; and it is still more meaningless to talk of energy being divisible, as if you could take a piece of energy in your hand and cut it in half. When, therefore, we come to study what have long been called the fundamental properties of matter, in the light of the work of the last ten—especially the last two—years, we find that these so-called fundamental properties are not fundamental, and that we reach a stage in our analysis of matter when they simply cease to have any meaning. One hesitates to use a word which has been employed by spiritualists and all sorts of spiritualistic quacks; but the fact is that, as a French observer has recently said, modern physics has accomplished the *de-materialisation* of matter, and having revealed it as something which is ultimately not material at all, has compelled us to modify all our old assertions as to what we used to call its fundamental properties.

We have spent much space on this subject here and in a previous lesson. The reader will find no reference to it in any ordinary text-book of physics, and may accuse us of not having a due sense of proportion; but the fact is that during the last year or two the fundamental notions of physics have undergone profound changes, and to ignore the consequences of these changes would simply be to ignore the most important and remarkable work that has been done in physics since the time of Newton.

Leaving now these exceedingly difficult and subtle questions, we may pass on to the consideration of other properties of matter which are of very great importance, but which fortunately are in many ways much easier to understand than those properties which we have already attempted to discuss. Let us simply content ourselves with the existence of molecules, using that word in the strict modern sense defined in the course on CHEMISTRY. On page 692 in that course we considered in a short paragraph the question of the actual size of molecules. Let us now pass on to consider the behaviour of molecules in general, not the behaviour of a molecule of water as distinguished from a molecule of, say, sulphuric acid—that would be more properly a chemical question; but here we are concerned with the behaviour which is common to all molecules, no matter what their chemical composition may be.

Nothing is at Rest. The first and most important fact, of the profoundest importance from every point of view—physical, chemical, and philosophical—is that all molecules are in movement. This is a fact upon which all students of the matter are agreed. In our previous chapters we have spoken of molar forces and properties; we have discussed motion and the laws of motion. As these words lie before you on the table they are at rest—the pages will not move unless something moves them; but if you could see the molecules of the pages you would find them to be all in active motion. Consider any mass of matter you please, such as a billiard-ball, and it may be at rest as a whole or in motion as a whole; these are molar rest and molar motion. But in all the matter that we know there is no such thing as molecular rest; there is nothing but incessant molecular motion. The molecules that go to make up the ivory of the billiard-ball are in incessant motion amongst themselves, no matter whether the billiard-ball, as a whole, is moving or at rest. Now, when we have completed our discussion of the properties of matter, we are going to consider the great subject of *heat*, and we shall find that this property, molecular movement, is of the very first importance in relation to the whole subject of heat. No one can possibly understand heat, or the great physical truths to which the study of heat has led us, without having a clear understanding that wherever there is matter, there is motion. Indeed, we shall not have proceeded far in our study of heat before we discover that what we call heat is none other than molecular motion.

Molecular Motion of Gases. First of all, let us consider matter in that physical state which we call gaseous. The molecules of a gas are in a state of much freer and more rapid motion then the molecules of a liquid or a solid. In a previous chapter we have discussed some aspects of the fact called fluid pressure. We have seen that those fluids known as gases always completely fill any space in which they may be enclosed. In this respect they differ profoundly from the fluids called liquids and from solids. It is believed, for the most excellent reasons of many kinds, that the characters of a gas, its pressure, the relation of its pressure to its temperature and its volume (previously described as Boyle's Law), and its behaviour in completely filling any space in which it is enclosed are consequences, one and all, of the molecular movement in the gas. We have to regard the molecules of every gas as rushing violently about in one direction and another, often striking one another or rebounding from the sides of any vessel that encloses them. We must beware, however, of forgetting Newton's law of motion. We must not conceive of the molecules of a gas as changing the direction of their motion at their own sweet will; they have to obey the law of inertia, and their movements and the course of the direction of their movements are determined by forces outside them. If a molecule of a gas moving onwards changes the direction of its motion, that is because it has collided with another molecule or with some solid body, such as the side of a vessel, or because some new force has been impressed upon it.

Molecular Motion and the Radiometer. Now, in a previous chapter, when we were discussing gravitation and the great discovery of radiation pressure, we referred to the radiometer of Sir William Crookes [page 938]. We saw that when heat is applied to the radiometer the delicately balanced vanes which lie in a partial vacuum inside the glass bulb begin to revolve, and it was asserted that this revolution was due to the fact that the remaining air inside the bulb is unequally heated, owing to the fact that one side of each vane is bright, whilst the other is blackened. The blackened side of each vane absorbs far more heat than the bright side, and so the molecules of gas that strike against the blackened sides are heated in a greater degree than those which strike the bright sides.

The effect of this heat—indeed, the very existence of this heat—imparted to the molecules consists in a more rapid molecular movement. The consequence is that as they rebound from the blackened sides of the vanes they acquire an additional speed, and since, according to Newton's law, action and reaction are equal and opposite, they, so to speak, kick the vane behind them as they leave it. The consequence is that the vanes are set into rapid movement, the bright side of the vane being the advancing side, since it is the black side that has been kicked, so to speak, by the heated molecules as they rebounded from it.

What the radiometer demonstrates, then, is, as we have already seen, not radiation pressure at all, but the molecular motion that occurs in every gas or mixture of gases, such as the air inside the radiometer.

Kinetic Theory of Gases. Now we must look further into this question of molecular motion in a gas. All the facts that physicists have observed have led them to frame what is known as the *kinetic theory of gases.* We need not define the word kinetic again, since the reader will remember its derivation from the Greek word implying movement. Now, the kinetic theory of gases asserts that the molecules of a gas are in constant movement, which is of the kind we defined in an earlier chapter as movement of translation—that is to say, not movement of rotation in one place, but movement, as a whole, from one place to another place. This movement of translation implies the possession of kinetic energy (a term already defined) by the molecules of the gas; and it is further asserted by this theory that the degree of this kinetic energy depends upon the amount of heat in the gas. Indeed, the amount of heat in the gas *is* the amount of kinetic energy of its molecules. In other words, the heat in the gas and the molecular motion of the gas are one and the same thing. Hence the total quantity of heat in a given mass of gas will consist of the sum of the kinetic energy of all the molecules that are contained in it. Further, the kinetic theory of gases helps us to understand the pressure of any gas or mixture of gases.

The Kinetic Theory and Gaseous Pressure. The pressure of a gas must be regarded as the consequence of the ceaseless bombardment of the surfaces which enclose that gas by its molecules. The pressure of the gas will vary, and indeed does vary, in accordance with this theory. [Compare Boyle's law, already referred to.] For instance, if we diminish the density of the gas—that is to say, the number of molecules in a given volume of it—we diminish its pressure. This must be so, simply because there are fewer molecules to exercise that bombardment of which we have spoken and upon which we have asserted the pressure of the gas to depend. Again, the pressure of the gas will diminish if we lower its temperature, and will increase if we raise its temperature. These facts are readily explained by the kinetic theory of gases, for when we lower the temperature of a gas we lessen the amount of heat in it—that is to say, we reduce the amount of molecular motion in it, or the amount of kinetic energy which its molecules possess; the pressure of the gas is reduced because the vigour of the bombardment is less. Similarly, when the temperature of the gas is raised there is more heat in it—that is to say, there is more molecular motion, more kinetic energy, a more vigorous bombardment, and therefore an increase of pressure.

Much attention has been paid to the actual speed with which the molecules of a gas move; it varies very widely in the case of different gases. At a temperature of 0° C. the average speed at which the molecules of hydrogen gas move is considerably more than 1 mile per second. The molecules of oxygen gas at the same temperature—molecules which, as the student on the course of CHEMISTRY will remember, have a mass 16 times greater than the molecules of hydrogen—have a speed one-fourth of that of the hydrogen molecules.

The "Free Path' of a Molecule. Now, we have stated that a molecule of hydrogen at the temperature of the freezing point of water would move considerably more than a mile in one second; but we must remember that it is surrounded by a host of other molecules with which it must often collide. Hence there arises this very interesting question. In any given gas, at any given temperature and pressure, what is the average actual distance through which a molecule can move before it strikes against another molecule and has its course changed? This average, or mean distance, is technically known as the *mean free path* of a molecule. Plainly, the more dense the gas be—that is to say, the more its molecules be crowded together—the shorter is the distance which the molecule can expect to travel in a straight line without, so to speak, bumping up against another molecule. Perhaps we may get a clear image of what must happen if we compare the conditions under which a skater can move in a crowded or a nearly empty skating rink. Now, it is stated that in the case of the molecules that go to form the gases of the air within the ordinary limits of the atmospheric pressure and temperature, the mean free path must be exceedingly short, amounting to perhaps about 1,000 times the incredibly minute diameter of a molecule. The number of collisions which any molecule must undergo in a second under such conditions must be almost immeasurable. If, however, we consider the molecules of the gases of the air that is present in the so-called vacuum of an ordinary incandescent electric lamp we find that the proportion of molecules to the space they occupy is so small that, were it not for striking against the glass itself, each molecule would have a mean free path of more than 30 ft.

No Cohesion in Gases. Now, let us consider the physical state of a gas and contrast it with the physical state of liquids and solids. If you move one end of a stick, the other end moves also, a most remarkable and wonderful fact, though it is such a common case that few of us have ever thought about it; but when we do come to think about it we see that there must be some intimate relation between the molecules of the stick, so that when one end of the stick is touched something is transmitted which compels the other end of the stick to move also. This property of the molecules of the stick we will call cohesion, and the first point to note *about the physical state of any gas is that its molecules have no cohesion. They are absolutely* independent of one another save for the fact that they are apt to interfere with one another by means of collisions; but it is evident that of cohesion—as the molecules of the stick have cohesion—they possess not a trace. In fact, then, the physical state of a gas, as compared with the physical state of a liquid or solid, is *relatively simple.* We have merely to conceive *of the gas as consisting of a number of independent molecules each possessed of energy of motion, or kinetic energy, in virtue of which it flies onwards in a straight line until it strikes* something which sets it on a new course in another straight line, and so on indefinitely. There is *no* cohesion between the molecules, and though we must believe that gravitation acts between them, there is nothing of what we shall soon learn to call *molecular attraction.*

Molecular Motion of Liquids. Now let us turn to consider the case of a liquid and the peculiarities of its physical state. Here, again, we may be absolutely certain that there is abundant molecular motion, and we must inquire into the differences between molecular motion in the case of a liquid and the case of a gas. But first of all let us notice a most important consideration, which will reappear when we come to consider the contrast between a liquid and a solid. We speak and think as if there were three states of matter—solid, liquid, and gaseous—the distinctions between them being absolute. But, of course, we cannot forget the fact that there are many solids, such as pitch, which pass by continuous stages from the solid to the liquid state. This, and many similar facts, together with our philosophical belief that Nature is not broken but continuous, and together with the conceptions which we must form as to what happens during the gradual process of evaporation of a liquid, or liquefaction of a gas or solidification of a liquid—all these considerations lead us to the very important conclusion that the transitions of ice, for instance, to the state of liquid water and then to the state of water vapour are absolutely continuous.

Transition from Solid to Gaseous. We are compelled to believe that all the stages between the solid and the gaseous state, which our reason compels us to assume, do really exist. The fact merely is that, as a rule, certain of these stages, such as the stages between ice and liquid water, are so rapidly passed through that unless very careful experiments are made for the purpose we fail to observe them. But the new science of physical chemistry has devoted much attention to this subject, and as the years go on we constantly become more and more certain that the so-called three states of matter represent not states that are absolutely distinct from one another, but states which are continuously connected by an unbroken series of gradations, certain of which happen to be very inconspicuous or so rapidly passed through that in the case of the majority of substances and under ordinary conditions we fail to observe them. Having insisted on this most important point, let us see what happens when a gas is liquefied Let us consider the most familiar instance which is that of water vapour or gaseous water.

Liquefaction of Water Vapour. The use of the two words gas and vapour is merely a matter of somewhat doubtful convenience, the word gas being applied to substances which are most familiar to us in the gaseous state, and the word vapour to substances in gaseous form which, however, are most familiar to us either as liquids or as solids. If, then, we consider the case of water vapour, we may ask what must happen when a given mass of water vapour is subjected to an increasing pressure? We will assume that the temperature remains the same, else our problem is complicated. As the water vapour is compressed, its molecules become crowded more and more together, until at last we may imagine that a point is reached when a certain number of molecules would become so crowded that the force called molecular attraction would be able to assert itself between them and their neighbours. The excellent illustration has been given of the case of some planet or comet conceived to be wandering through space in a free path. By chance it comes within a certain distance of some other body, such as the sun, and gravitational attraction asserts itself to such an extent that the wanderer loses its freedom of movement and is compelled to enter into a special relation with the attracting body—such, for instance, as the relation which the earth holds to the sun as she travels round him. Now, some thing like that happens when the water vapour we are considering is compressed beyond a certain point.

Molecular Attraction. In the case of a molecule here and a molecule there, and gradually in the case of more and more molecules, the force of molecular attraction, whatever that really may be, comes to assert itself, and a new state of affairs is gradually set up, in which the water vapour gradually loses the character of a gas and assumes the character of a liquid. We must thus believe that the molecules of a liquid have become entangled with each other in the same sense as the earth is entangled with the sun. Previously they were able to move in any direction, and had so much kinetic energy of their own that they could even fly upwards, notwithstanding the force of the earth's attraction. But now they have lost their momentum and have established a new relation with each other. Gradually the process of liquefaction continues, in accordance with the assertion we have already made that the transition from the gaseous to the liquid state is gradual and continuous. When the total volume of water vapour has been sufficiently reduced, we find that it is no longer water vapour, but liquid water. Exactly the same results as have been achieved by increasing the pressure without alteration of the temperature would also have been achieved by reducing the temperature—that is to say, by reducing the amount of kinetic energy in the molecules—even though we had not subjected the water vapour to any increase of pressure.

How, then, are we to conceive the physical state of a liquid, and what is the nature of the motion of its molecules? They are no longer moving in *free* paths, long or short; the force of molecular attraction has been asserted, and the molecules are probably moving in complicated orbits round each other at a speed which, though very great, is less than the speed at which they formerly moved when enjoying the complete mutual independence possessed by the molecules of a gas. Well indeed it would be if we could now explain the exact nature of this force which we call molecular attraction. Ultimately, no doubt, it will be shown to be an electrical phenomenon, but that time is not yet.

The Process of Freezing. Next we must consider what happens when the liquid water becomes solid. Precisely the same change of conditions as turned the water vapour into liquid water will, if made more marked, yield us ice in its place. The essential difference between the solid and the liquid states is that the solid is possessed of less molecular motion than the liquid, so that the forces of molecular attraction are enabled still further to assert themselves. Let us turn to the illustration from astronomy. What would happen at this moment if the kinetic energy of the earth in its orbit was reduced or completely removed? In the first instance gradually, by a sort of narrowing spiral, and in the second instance immediately, by motion in a straight line, it would fall into the sun. A process exactly parallel to this is what happens where, by abstracting heat from liquid water—heat being none other than a form of kinetic energy—we reduce the kinetic energy of its molecules to such an extent that molecular attraction asserts itself still further, and their orbital motion around one another ceases. The consequence will be that the molecules come closely together, so closely that they cohere, and if we move one end of the block of ice that is formed, the other end, in virtue of this cohesion, will move also.

Molecular Motion of Solids. Now, are we to regard the motion of the molecules in the solid so formed as having ceased? Most assuredly not. Though the kinetic energy of the molecules has been so much reduced that they can neither fly about independently of each other as in a gas, nor yet revolve in orbits round each other as in a liquid, yet some kinetic energy still remains to them. Much heat has been abstracted from the water, but by no means all. There are many colder things than ice, and all ice is not at the same temperature. Probably we must regard the molecular motion of such a solid as ice as consisting of a to-and-fro or vibratory motion of pairs or groups of molecules. Pray observe the use of the word groups. For consider what is really the physical state of ice, which consists of crystals. These crystals must consist, in their turn, of regularly arranged groups of molecules, harmoniously vibrating with one another. The precise manner of their vibration will determine, we must suppose, the shape and size and other characters of the crystals of ice or any other substance.

The Result of Solidification. It is scarcely necessary again to insist that, as in the previous case, the process of solidification is a gradual one—first one molecule and then another being so far deprived of its kinetic energy, as heat is abstracted from the mass, that it can no longer maintain its orbital motion. But suppose that the process has been completed and that the whole mass is now solid, and suppose that we continue the process of reducing the temperature, and thus remove still more energy of motion or kinetic energy from the molecules of the ice. The result will be that their vibrations or to-and-fro movements will become less extensive, and the ice will shrink or contract. It is the general rule that when a body is heated it expands, and that when it is cooled it contracts. These facts can readily be explained on the theory of molecular motion: as heat, kinetic energy, motion, continues to be removed from the ice, it continues to shrink more and more, thus showing that its volume—the very space it occupies—is determined, partly at any rate, by the motion of its molecules. What will happen next?

The Coldest Cold. Now this is a fascinating and most important question. Suppose that we go on abstracting heat or molecular motion from any body, we must ultimately reach a point when there is no more heat or molecular motion in it—that is to say, when its molecular motion has been absolutely abolished. Such a body, and such a body only, would be absolutely cold, being destitute of all heat or molecular motion. But the study of this great question must be deferred for the present, until we have made a further study of the facts of heat. For the present it will serve, perhaps, to keep alive the reader's interest in this subject if we say that the absolute zero of temperature has never yet been reached by anyone, and that it seems more than probable that the attempt to reduce any substance, even frozen hydrogen, to this ultimate depth of cold, must for ever fail. As to the aspects which matter would present if deprived of all its molecular motion no one will dare positively to say; but of this more anon.

Molecular Forces in Detail. Perhaps the reader may be apt to think that molecular forces, because they are displayed in exceedingly small bodies, can have no very great magnitude. But that would be a very great mistake. Let him consider, for instance, the strain to which steel is exposed in many of its industrial applications; let him consider the number of tons which a steel wire will support—yet what is it but molecular attraction that keeps together the molecules of steel, even though such a tremendous strain is put upon them, endeavouring to pull them apart? We must clearly understand that though molecular forces act only at very minute distances, yet within those distances their power is gigantic. Gravitation, which we so constantly think of as tremendously powerful, is almost a negligible quantity when it is pitted against molecular attraction. When a great weight is supported by a steel wire it is evident that, *if we consider any level in that wire, the molecular forces of that level are sufficient to more than counteract the weight*—that is to say, the expression of gravitation—of all the mass of wire below that level and of the body that hangs at the end of it. We have chosen solids for our illustrations because it is in them that the molecular forces are so powerful, but they are very far from being negligible in many liquids.

Surface Tension. Every reader is familiar with the fact that a tumbler may be filled with water so full that the surface of the water is visibly higher than the edge of the tumbler, yet the water does not run over; though, if the finger be applied to the edge of the tumbler and the *surface* of the water be thus broken, some of it will run over the edge of the glass at the point where the finger was applied. This fact is a familiar illustration of the result of molecular attraction as it exists at the surface of a liquid. The technical name for it is *surface tension*, and its power may be measured by measuring the force which can be applied in such a way as to cut the surface of a liquid, but which, in virtue of surface tension, fails to do so. A thoroughly well greased needle, very gently placed on a still surface of water, will form a groove for itself, and lie on it without sinking. Now, how are we to explain this fact of surface tension? Why does the surface of the liquid look as though it were covered with an elastic skin made of the same stuff as itself? The surface of the liquid is composed of a number of molecules, and these have the mutual relations which we have already described. Immediately above the free surface of the liquids, as in the case of the filled tumbler, there are innumerable molecules that constitute the various gases of the air. Now, if we consider any molecule of the liquid, we see that it is attached by, and held to, the other molecules that are around and below it, whereas, on the other hand, it is not at all attracted—or, at any rate, not in anything like the same degree—by the gaseous molecules that are above it.

Formation of Drops. This fact of surface tension explains not only the curved surface of water in a full tumbler, but also, for instance, the fact that when water slowly falls it does so in drops. The formation of these drops and their curved external surface depend upon the fact that all the molecules of the liquid are, so to speak, bound to one another, whilst no force from outside tends to counterbalance their mutual attractions. Hence the surface of the liquid takes the shape which has the smallest possible area. Gravitation to some extent complicates the matter, so that often the drop is not completely spherical, but bulges a little at its lowest point. This familiar fact of surface tension has its uses, for upon it depends the process of making shot, which is accomplished by allowing a quantity of molten lead to fall through a sieve from a height into water. Gravitation in this case is negligible, and as the drops of lead fall and cool they solidify in the spherical shape which is imposed upon them by surface tension.

Results of Surface Tension. The case of water whose free surface is in contact with air is a simple and familiar one, but the number of different conditions in which surface tension may display itself is endless. Take, for instance, the surface formed by the contact of a liquid and a solid. If the solid be flat and perfectly free from grease, the various surface tensions are such as not to prevent many liquids from spreading themselves out upon it, or, as we say, wetting it; but if we take such a liquid as mercury, the relations of surface tension between it and the air and a flat surface on which a drop of it may be placed are such that the drop retains its form, and does not wet the surface. Similarly, water will not wet the surface if that be greasy. Briefly, we may note one or two other facts of surface tension—such as, for instance, that a rise of temperature diminishes this force, this being precisely what the reader would expect if he recalls what has been said as to the effects of temperature, or, rather, amount of heat, upon the movements and relations of molecules. Lastly, we may refer to soap bubbles—bubbles which consist of thin films of soapy water arranged in bubble form under the influence of surface tension—that is to say, the relation between the molecules of the water and the soap in the mixture, and their greater attraction for one another as compared with their attraction for the gaseous molecules within and without the film which constitutes the soap bubble.

Continued

ENGLAND AND WALES

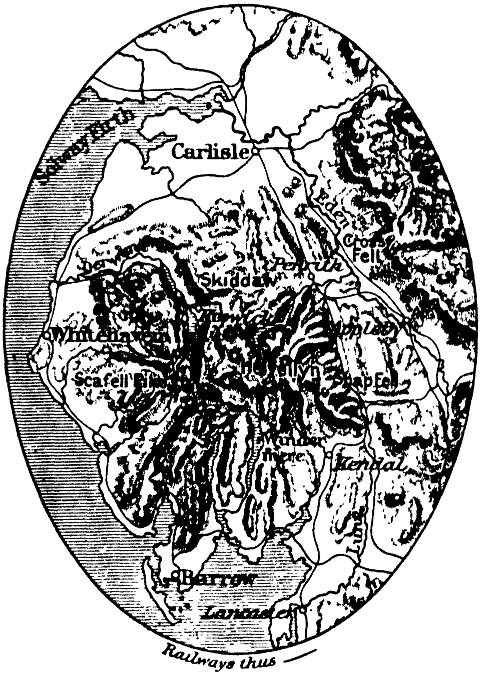
The Lake District. The Pennines. The Principal Coalfields. The Midlands. The Thames Basin and Estuary. The Severn. North and South Wales

Continued from page 1068

By Dr. A. J. HERBERTSON and F. D. HERBERTSON, B.A.

ENGLAND

The Lake District. Along the Scottish Border are the Cheviot Hills, the link between the Southern Uplands of Scotland and the Northern Uplands of England. Their rounded summits rise to 2,500 ft. To the south is the Eden Valley, with Carlisle, the centre of an agricultural district, controlling all routes north and south. The Shap Pass, about 1,000 ft., leads from the Eden to the Lune basin, and the plain of Lancashire. The Eden and Lune valleys almost separate the Cumbrian mountains of Cumberland and Westmorland from the Pennines proper, the Shap Fells uniting the two in the centre. The Lake District is a district of bare mountains, often with terrible precipices, and long valleys filled by beautiful lakes. Innumerable streams, fed by the constant heavy rains from the Atlantic, course down the mountain sides, leaping from crag to crag in the waterfalls for which the district is famous. Skiddaw, rising above Lake Derwentwater, Scafell, above Wastwater, and Helvellyn, near Ullswater, the grandest of the lakes, are all about 3,000 ft. high. The climate is too wet and cold and the soil too scanty for agriculture, but there is much sheep-farming. Summer brings thousands of tourists, who congregate at Keswick, on Derwentwater, and Ambleside, on Windermere, the largest of the lakes. Kendal, once famous for its woollens, still manufactures friezes, procuring its coal by canal from the Lancashire coalfield.



71. THE LAKE DISTRICT

The Pennines. The Pennines run from the Scottish Border far into Derbyshire, with lowlands on either side extending to the sea. They are separated from the Cheviots by the Tyne valley in the north, and are divided into two masses by the Aire valley in the centre. The scenery varies with the character of the rocks, and is most picturesque in the limestone. Much of the Pennines consists of hill pastures, diversified by heather moors, and mosses or bogs. The highest points—Cross Fell, Bow Fell, Whernside, and Ingleborough—all north of the Aire, are between 2,000 and 3,000 ft. The picturesque Peak District of Derbyshire to the south is just over 2,000 ft. Here the rock is limestone mixed with millstone grit, a name which explains itself. "The edges form wild, craggy cliffs, with deep river gorges winding far back into the heart of the plateau. The upper surface is covered with a considerable thickness of peat, through which bosses of grit project, which have been worn into wild and fantastic forms." In the limestone districts of the Peak are immense caves, numerous underground rivers and steep-walled dales, like Miller's Dale, near Buxton. Mineral springs occur at Buxton and Matlock in the Peak, at Harrogate and Ilkley in Yorkshire, and elsewhere in the Pennines.

The Marginal Coalfields of the Pennines. On either side of these lonely uplands are busy industrial regions, darkened by day by the smoke of mill chimneys, and lit up at night by the glare of blast furnaces, all fed by the coal which abounds on both flanks of the Pennines. The iron industry in all its many branches, including shipbuilding on the coast, is very general. Cotton, brought across the Atlantic to Liverpool, and, since the cutting of the Ship Canal, to Manchester, is manufactured on the South Lancashire coalfield. In the Yorkshire valleys opening from the eastern Pennines the woollen manufacture is important.

The Western Fields. The Cumberland coalfield extends along the sea from Maryport to Whitehaven, the workings round Workington being carried under the sea. To the south, in the rugged Furness district of North Lancashire, on the margin of the Lake District, the abundance of red hæmatite iron has created the town of Barrow, which, 50 years ago, before the invention of the Bessemer process, was a fishing village. Among its many iron industries are smelting, shipbuilding, and the manufacture of ordnance, some works being on Walney Island, off the coast. Barrow is a busy port, and has steamer services to Irish Sea ports.

The South Lancashire Fields. Lancashire is flat and sandy along the coast, but rises to over 2,000 ft. in the north and east. Except on the coalfield, which covers 400 sq. miles between the Ribble and the Mersey, it is pastoral in the uplands, and agricultural in the lowlands, raising potatoes and oats. Lancaster, the county town, is hampered as a port by the silting of the Lune estuary. Heysham and Fleetwood, on the shallow Morecambe Bay, are ports and packet stations. Blackpool and Southport, north and south of the Ribble estuary, are crowded seaside places. At the head of the Ribble estuary is Preston, with important docks, engineering works, and cotton mills. Its frequent horse and cattle sales indicate its position on the margin of the agricultural region. Crowded on the coalfield to the south, and engaged in manufacturing cotton or iron (machinery, railway plant, etc.), or both, are Clitheroe, Burnley, Blackburn, Bury, Bolton, St. Helens, Oldham, Warrington, and Manchester, with Stockport and Staleybridge over the Cheshire border. Manchester, the industrial capital of Northern England, is less a manufacturing centre than a market. Its rival is Liverpool, with Birkenhead, near the mouth of the Mersey estuary, the focus of transatlantic trade and passenger traffic. Both the Liverpool and Birkenhead sides of the estuary are lined with docks and warehouses, which receive not only cotton, but grain, tobacco, leather, live and dead meat, and whatever the Atlantic coasts of the New World have to send, in addition to produce from other parts of the world.

The Cheshire Plain and North Staffordshire Coalfield. The Cheshire plain, an extension of the Central English plain, opens a way between the Pennines and the Welsh mountains. Except on their margin, it is an undulating meadow region, noted for cattle and dairy produce, including Cheshire cheese. Coal crops out in the east on the Peak margin, where silk and cotton are manufactured round Macclesfield. Rock salt is worked round Northwich, Nantwich, and elsewhere. Coal becomes more abundant in North Staffordshire, where it supplies the pottery towns, Burslem, Hanley, Stoke-on-Trent, etc., all making earthenware and china.

Northumberland-Durham Coalfield. Both Northumberland and Durham are rugged in the west, where Cheviot sheep and Durham cattle are bred. In the valleys opening to the lowlands barley, wheat, beans, turnips, and potatoes are grown in the rich clayey loam. Fishing towns and ports for coasting traffic dot the coast. The chief river is the Tyne, with two head streams, North Tyne from the Cheviots, and South Tyne, which has cut a valley across the Pennines, followed by the line from Newcastle to Carlisle. At its estuary are the Tyne ports, Newcastle, Tynemouth, Jarrow, and South Shields, the outlet for the manufactures of the rich coalfield. These include iron in all branches, hemp and wire rope, glass, chemicals and pottery. Much coal is exported. Newcastle, with Gateshead on the opposite bank, is engaged in all these industries. At Elswick, a suburb, are the Armstrong ordnance works, where the most powerful guns are made. Sunderland and the Tyne ports, Stockton and Middlesbrough, are similarly engaged in working up the iron which abounds in the Cleveland Hills of North Yorkshire. The combination of cheap coal and iron is rapidly attracting shipbuilding away from the Thames, where freight makes both costly, and concentrating the industry on the Tyne and Tees. Darlington manufactures woollens and carpets, as well as iron and steel. In striking contrast to these smoky industrial towns is Durham, on a height above the Wear, with a glorious cathedral, and old-world streets and houses.

The York, Derby, and Nottingham Coalfield. The eastern slopes of the Pennines are drained by a series of parallel rivers, Swale, Ure, Nidd, Wharfe, Aire, and Calder, whose valleys gradually widen from narrow dales of wild beauty to broad and fertile lowlands. In these valleys, as in the Tweed basin, where the conditions are similar, the woollen manufacture has long been important. The wool was supplied by the hill pastures above, and the river was there to turn the mills. Now, especially in the Aire and Calder valleys, water power is replaced by steam. The Yorkshire coalfield, between the Aire and the Don, covers an area of 45 miles by 20. The chief woollen towns are Keighley, Leeds, Bradford, Huddersfield, Halifax, and Dewsbury. Linens are made at Leeds and Barnsley. Cutlery, electro-plate and hardware are made at Sheffield and Rotherham, near the borders of Derby and Nottingham. In these counties, both rich in coal, the Pennine landscape gradually gives place to that of the plain. On the Derbyshire field collieries disfigure many a lovely valley. Silk is manufactured round Chesterfield, and in Derby, where brewing is also important. On the Nottingham field the manufactures are lace and hosiery, both carried on at Nottingham, on a tributary of the Trent.

The Vale of York. The rivers named above unite to form the Ouse, the main stream of which flows across the rich Vale of York parallel to the base of the Pennines. From the east comes the Derwent, flowing between the Yorkshire Moors, rich in iron, and the Yorkshire Wolds. The Vale is very fertile, and both agriculture and dairy farming are important. It is dotted with prosperous market towns. York, on the Ouse, with remains of the Roman city and a magnificent cathedral, is the focus of the district, and the seat of an archbishopric. In the rugged east, the towns are found along the coast, which, as far as Flamborough Head, is high and picturesque, and dotted with seaside resorts, of which Whitby and Scarborough are the most popular. South of Flamborough Head the low district of Holderness grows fine crops of wheat, beans, and hay, while barley and turnips do better on the higher Wolds. On the Humber, the broad estuary of the Yorkshire Ouse and the Trent are Goole and Hull, both busy fishing and trading ports and shipbuilding centres. Hull, besides an enormous trade by sea with the chief ports of Western Europe, carries on a large number of flourishing industries. The proximity of the Dogger banks makes the fisheries important all along the coast.

The English Plain. We now pass from the uplands to the lowlands of England. In the north they are cloven by the Pennines into the Lancashire and Cheshire plain in the west, and the plain of Yorkshire on the east. South of the Pennines they extend from the base of the western mountains to the North Sea, broken by occasional lines of heights. Here the population is concentrated, densely on the coalfields, more sparsely in the agricultural districts. The plain, outside the coalfields, is dotted with numerous towns, many very ancient, sometimes with manufactures of some importance, but always the focus of the traffic, trade, and political life of the surrounding district. Before the days of railways many, like Birmingham, Coventry and Norwich, had a very intense local life, and a highly intellectual society. Now London attracts the best elements, and provincial life is correspondingly impoverished.

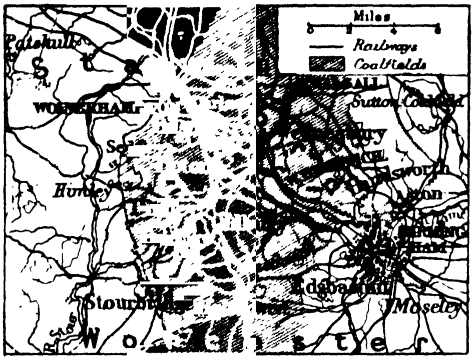
The Lincolnshire Fenlands. Lincolnshire occupies the angle between the Humber and the Wash. Much of it is a low plain, largely composed of fenland. Many canals and dykes have been cut to drain it, and along the sea it is often embanked to keep the sea out. In the centre the chalk, which covers much of southern England, crops out in the Lincolnshire Wolds, rounded hills with sheep pastures, and further west in the ridge of Lincoln Edge. Famous breeds of horses and cattle are kept in the rich, moist, low-lying meadows. Corn is largely grown.

Some Typical Towns. Lincoln, the county town, an ancient city with a fine cathedral, is built on a height, where the Witham cuts through the Lincoln Edge and becomes navigable. Its industries illustrate the relation of such a town to the district around. Its ironworks and manufactures of farming implements and machinery show how the needs of a farming country create local industries to supply them. Its steam flour mills and breweries show how agricultural produce is locally worked up. In spring, a horse and cattle fair lasts several days, and there are frequent corn, wool, and stock markets. This illustrates the distributing centre.

The Foss Dyke, from the Witham, near Lincoln, to the Trent, connects the counties of the Trent basin with Boston, on the Wash, at the mouth of the Witham, a fishing port, exporting grain, and - manufacturing sailcloth, leather, and ropes. Such industries, as well as boatbuilding, are found in almost every coast town. Fishing is important all along the coast. The chief market is Grimsby, near the mouth of the Humber, from which fish trains run to the inland towns. Grimsby trades chiefly with the North Sea and Baltic ports. Besides fish, it exports, among other things, cotton and rubber. These have been brought originally from African or American ports to Liverpool, worked up on the Lancashire coalfield, forwarded by the lines which cross the Pennines, and finally shipped from this East Coast port to the opposite shores of Europe. Of the imports, note butter, from the meadows of Denmark and Holland, and timber, from Scandinavia and the Baltic. The trade of Grimsby is thus an instructive commentary on its geographical position. The reader should similarly endeavour to think out for himself the actual or possible relations of his own district to the larger world without. A sub-port of Grimsby, collecting its exports and distributing its imports, is Gainsborough, on the Trent, an inland town on the map, but really built where the river is still tidal. Here Baltic timber is stored in timber-yards, or sawn in saw-mills, while other commodities are shifted from steamer to barge, or vice versâ, for the Trent is one of the great arteries of eastern England. It rises in the western Pennines, and flows round their base, receiving many tributaries, of which those from the Peak come down in lovely parallel dales and valleys. It is navigable as far as Burton, the famous brewing town, in the very heart of England, which is thus, by means of the Trent and the canals connected with it, brought into direct communication with the sea.

The Midlands. Under this term we may include the shires of Northampton, Rutland, Huntingdon, Bedford and Cambridge—drained to the Wash—Leicester and Stafford in the Trent basin, and Warwick in the Severn basin, the two latter containing the Midland coalfield. The east is the richest agricultural district of England. Of the rest much is in grass, forming ideal hunting country, hunted by many famous packs. It is separated from the Thames basin by the Cotswold and Chiltern Hills, with lower heights between. In the east the Welland, flowing past Stamford, the Nen, past the cathedral city of Peterborough, and the Great Ouse, past Bedford, St. Ives, and the cathedral town of Ely, all rising at no great elevation, flow sluggishly to the Wash. Much of their basins consists of marsh and fen land, reclaimed at great expense by cutting innumerable canals and trenches, or dykes, and forming a rich, black mould of great fertility. The so-called Isle of Ely, consisting of somewhat higher ground, was anciently entirely cut off by marshes, whence its name. It is now the centre of a fruit and vegetable growing district, with jam factories. Cambridge, on a tributary of the Ouse, is a university city with fine mediæval architecture. The basin of the Ouse contains some of the finest agricultural land in England, and wheat and other cereals are largely grown.

Associated industries are straw-plaiting, round Dunstable, in Bedfordshire, and brewing, which is very widely distributed. Dairy farming is almost as important. Stilton cheese is made near Melton Mowbray, in Leicestershire, and other associated industries are the fattening of cattle for the London market, and the boot and shoe industry of Northampton, Leicester, and Kettering. The very fine, long, staple wool of the Leicester sheep makes hosiery an important manufacture at Leicester. Outside the coal area, Warwickshire presents the same character. The county town is Warwick, with a famous castle on the Avon, near Leamington, with mineral springs, the ruined castle of Kenilworth, and Stratford, the birthplace of our national poet. As Shakespeare's country, it attracts many tourists. The cycle trade is important at Coventry. All these counties, with their park-like landscape, golden wheatfields, rich meadows, and ancient, somewhat sleepy towns, seem little changed by the coming of steam, and recall an England which has elsewhere largely disappeared.



72. THE BLACK COUNTRY

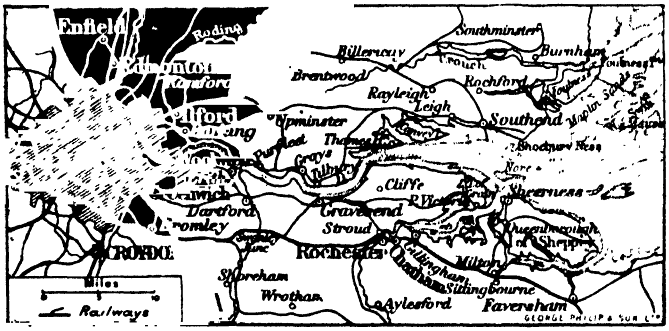
The Midland Coalfield. Very different is the scene on the coalfields of North Warwickshire and South Staffordshire. Vegetation is blasted, and a pall of smoke overhangs squalid towns of mean houses, little redeemed by the fine administrative buildings and the luxurious villas of the west end—the fashionable, because, with our prevailing west winds, the least smoky quarter. Though known under different names, the various collieries all form part of one extensive field. Iron is everywhere abundant, and so is the limestone required as a flux. Iron smelting and the iron manufacture in all its countless forms are carried on in a ring of iron towns rapidly growing into one unsightly whole—Birmingham, West Bromwich, Wednesbury, Walsall, Wolverhampton, Bilston, Tipton, and others—forming what is fitly called the Black Country.

East Anglia. East of the Midlands are the maritime counties of Norfolk and Suffolk, once part of East Anglia, with which we may include Essex outside the metropolitan area. All are, for the most part, flat, especially beside the sea, which encroaches on the land. Round the shallow Wash thousands of acres have been reclaimed. Beyond the Fen district, on the east coast of Norfolk, are the Broads, a region of shallow lakes and reedy marshes, teeming with wildfowl. Many rivers, rising in low heights to the west, flow east, opening to an estuary, with a port at the head, or mouth. Such are, among others, the Yare, with Yarmouth; the Orwell, with Ipswich; the Stour, with Harwich, the packet station for the Rhine and Elbe ports; the Colne, with Colchester. Similar in type, but called to a greater destiny, is the Thames, with London. The whole region is engaged in (1) agriculture, growing cereals and other crops, especially a fine malting barley; (2) grazing famous breeds of horses; (3) fishing, with its accompanying industries; and (4) the tourist industry, which is important all round the coast. The centres of the herring fishery are Yarmouth and the artificial port of Lowestoft. Of inland towns, note the cathedral city of Norwich, on a tributary of the Yare; and Chelmsford, on the Chelmer.

The Thames Basin. The Cotswold Hills, with lower heights to the north-east, separate the Thames from the Severn basin. They rise steeply from the western plain, exposing their bare limestone ribs, topped by short, dry pastures on which sheep are kept, and slope gradually to the south-west. The main stream of the Thames rises near Cheltenham, and receives the Cotswold streams, Windrush and Evenlode, from hilly pastoral districts, with small towns engaged in manufacturing the wool and skins they produce. Thus gloves are made at Woodstock, and blankets at Witney on the Windrush. Oxford is built where the Cherwell comes in, having risen in the Northamptonshire heights, and flowed almost due south. It is a famous university city of great antiquity and beauty. Beyond its confluence with the Thame, a few miles below Oxford, the Thames cuts through the chalk, separating the Chiltern Hills on the north-east from the Marlborough, or White Horse Downs, on the west. At Reading it receives the Kennet, which flows in a valley between the chalk heights of Wiltshire and Berkshire. After passing near Windsor, with its famous Royal castle, the Thames receives tributaries from the Chilterns to the north. Flowing northwards, across the North Downs to the south, come the Wey, Mole, and Medway, forming gaps through these heights, which are used by the railways to the south coasts. In the picturesque lower reaches, Hampton Court, Twickenham, and Kew are names familiar to Londoners. The houses grow more numerous, and the river widens, until at London Bridge it is nearly 800 feet wide.

London. London, like Oxford, or Ely, was built originally among defensive marshes, on higher, firmer ground, and like Glasgow, at the lowest point at which the river could be bridged. A little above it grew up the city of Westminster, round a much used ford. The two are now continuous, but have separate administrative bodies. To describe London would require many pages. Its claims to rank as a beautiful city are based on (1) St. Paul's, in the City of London, rising above the Thames, not far from the Tower, an ancient fortress and former Royal residence; (2) the group of buildings fronting the river at Westminster, including the ancient Abbey and the Houses of Parliament, to which will soon be added the palatial home of the County Council on the opposite bank; (3) a few fine streets opening west from Trafalgar Square, considered one of the finest sites in Europe; (4) the group of Royal parks in the fashionable west end. Beyond lies a wilderness of mean streets, extending miles in all directions. Beyond these again, on north, west, and south, are pleasant suburbs. London is one of the great ports and markets of the world, and one of its chief financial centres. It is also the centre of national and imperial government, and the heart of our world-wide empire.

The Thames Estuary. In central London, the banks of the river are embanked and planted with trees, forming pleasant promenades. East of these come wharves, warehouses, docks, and the factories engaged in the many industries of a great seaport. Woolwich, on the right bank of the estuary, where the river is nearly twice as broad as at London Bridge, has an immense arsenal. Gravesend is a busy river port. Queenborough, on Sheppey, once an island, is a packet station for the Rhine ports. Shoeburyness, on the opposite bank, is a station for artillery practice. Sheerness, on Sheppey, strongly fortified, has barracks, dockyards, and arsenals. Chatham, at the mouth of the Medway, forming with the cathedral city of Rochester a single town, is the naval arsenal. There are many cement and brick works in the neighbourhood. Further east are numerous seaside resorts, Whitstable, with oyster fisheries, Herne Bay, Margate, and Ramsgate. Beyond Ramsgate, the chalk cliffs continue intermittently round the south coast as far as Lyme Regis, on the border of Dorset and Devon.



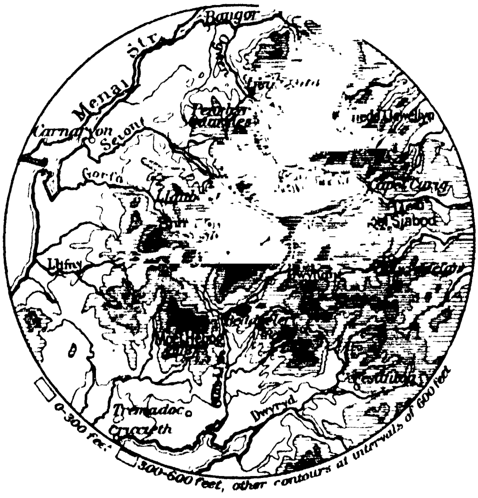
73. ESTUARY OF THE THAMES

The dotted area along the coast denotes the foreshore, which is uncovered at low water

The Channel Counties. Nearly all the towns just named are in Kent, often called the Garden of England. The Weald, formerly covered with forests between the North and South Downs, is very fertile. Cereals, fruit, and hops are grown. On the North Downs fine sheep are bred. Towns are numerous, both inland and on the coast. Maidstone, on the Medway, in the centre of the hop district, has important breweries. Canterbury, on the Stour, with a magnificent cathedral, is the ecclesiastical capital of England and seat of the chief archbishopric. On the coast are the ports of Deal, Dover, and Folkestone, the two latter Channel packet stations. Surrey, drained to the Thames by the Wey and Mole, which have cut gaps across the North Downs, has fine pinewood scenery. Sussex is drained to the Channel by short rivers cutting through the South Downs. Towns are numerous, especially on the coast. Notice Hastings, Eastbourne, the packet station of Newhaven, Brighton, and Worthing. Chichester, a cathedral city, is connected with the coast by a short canal. Hampshire, also a chalk county, is drained to the Channel by rivers flowing south from the Downs in the north. Note the indented coast, giving many good and two magnificent harbours. Portsmouth Harbour has an entrance 1½ miles wide, and is our chief naval base in the Channel. It is very strongly fortified. Portsmouth is the garrison town, Portsea the naval dockyard, Landport the artisan quarter, and Southsea a watering-place. On the opposite side of the harbour is Gosport. Portsmouth commands the entrance to Spithead, which, with the Solent, separates the mainland from the garden Isle of Wight, with the inland capital of Newport, and many summer resorts round the coast, including the yachting centre of Cowes. Both these straits open to Southampton Water, the Itchin estuary, with the great port of Southampton at its head. This is the packet station for most of our colonies and for the ports of the Indian, Pacific, and South Atlantic Oceans. The largest liners afloat can enter and leave at all states of the tide. Bournemouth, with pine woods, is a winter resort. Inland the chief town is Winchester, on the Itchin, with an ancient cathedral. It was originally the capital of England.

Dorset and Wiltshire. Dorset and Wiltshire form the south-western extremity of the chalk heights which cross the English lowlands. The rivers flow south, cutting gaps through the chalk heights. At most of these, towns are built, some, like the cathedral city of Salisbury, of great antiquity. These heights are known under many names, as, for example, Salisbury Plain, a moorland district on which is Stonehenge, an ancient stone circle. Grazing and dairy farming are important in the valleys, both Dorset and Wiltshire butter and bacon being famous. The sheep fed on the hill pastures supply wool for the woollen manufactures of Trowbridge, Bradford, and other towns, carried on with coal from the Bristol coalfields. Fishing and seaside towns line the coast, the most fashionable being Weymouth.

The West Country. Somerset is a transition county, resembling the Severn basin in the north, and in the Exmoor district passing into the scenery of Devon and Cornwall. It is a hilly county, with vales opening to the sea, the most fertile being the Vale of Taunton, famous for hops, fruit, and fine wheat. Bath is built on the gorge of the Avon, where excellent stone is quarried. Bristol, at the head of the Avon estuary, has long been a famous port. Early in our history it exported the wool of the surrounding sheep-farming counties, and supplied much of Catholic Europe with fish. The discovery of America increased its importance, and it now trades with every part of the world, especially across the Atlantic. Among its many manufactures are tobacco, cacao, sugar refining, all depending on its imports. Shipbuilding, engineering works, chemical works, and soap and glass making are among its other industries.



74. SNOWDONIA

The elevation of the land is shown by the tints. The darker the tint, the greater the elevation. The solid black shows the land over 3,000 feet

Devon and Cornwall. Devon and Cornwall are maritime counties. Much of the interior is high, bleak moorland, forming the highlands of Dartmoor (1,700 ft.), with hardy breeds of ponies, sheep, and cattle; Exmoor, where deer are still semi-wild; and Bodmin Moor. Round these centres woollen towns tend to grow up, as at Axminster, in South Devon, where carpets are made. Honiton, not far off, makes lace. In the steep-sided valleys opening from the highlands the red earth is very fertile. Dairy farms and orchards supply Devonshire cream and Devonshire cider. The rivers enter the sea by picturesque winding estuaries, each with its fishing town. Notice Barnstaple in North Devon, and in South Devon, Axmouth, Sidmouth, Exmouth on the Exe, with the cathedral city of Exeter, the capital of the West Country, higher up the river; Teignmouth, Dartmouth, and especially Plymouth, built where the Tamar estuary forms Plymouth Sound. With Stonehouse and Devonport, Plymouth ranks next to Portsmouth as a naval station, and rivals Southampton in its world-wide communications. It is strongly fortified. Other coast towns are Torquay, a winter resort on Tor Bay, opposite Brixham, the centre of the trawl fishery. Cornwall prospers mainly by its fisheries, including pilchard and mackerel, and its tourist traffic. The tin and copper mines famous in antiquity are now little worked, and many miners emigrate. The towns are chiefly on the coast. Falmouth Harbour, with Falmouth at the mouth, and Truro at the head, recalls Plymouth Sound. Penzance and St. Ives lie in the extreme south-west, and are centres of pilchard fishing. The Scilly Isles, 150 in number, but few inhabited, engage in fishing and in growing early vegetables and fruit.

The Severn Basin. The Severn rises in a small lake on Plynlimmon, in the heart of the Welsh Highlands, whose sheep pastures feed the woollen towns Newtown and Welshpool. Shrewsbury, commanding the route across Cheshire into North Wales, had one of the many castles built along the Welsh Border, or March, of which Ludlow, Monmouth, and Chepstow may also be mentioned. The Severn flows through a picturesque district, between the Shropshire and Stafford heights, where coal and iron are worked in Coalbrookdale, and some wool is manufactured, as at Kidderminster, and then enters a broad vale between the Malvern Hills and the Forest of Dean on the west, and the steep Cotswolds on the east. On the right bank picturesque tributaries descend from the Welsh Highlands. The Teme flows past Ludlow, and enters the Severn not far below the cathedral city of Worcester, with famous porcelain works. The Wye, from Plynlimmon, rivalling the Rhine in beauty, flows by the cathedral city of Hereford, in a hop and orchard country, Monmouth, Tintern, and Chepstow to the estuary, which the Usk, with Newport as its port, also enters. On the left bank sluggish streams cross the central plains from low heights which separate the Severn basin from those of the Trent and the Wash rivers. The Avon, the largest, flows by Warwick and Evesham, in a rich orchard country, to the Severn at Tewkesbury. Wool is manufactured in Stroud and other Cotswold towns, with coal from the Forest of Dean, which also supplies Worcester. Cheltenham has mineral springs and famous schools. Gloucester, at the head of tidal navigation, with a fine cathedral, is a port. The Severn Bridge, nearly a mile long, crosses the estuary at Sharpness, and further south a tunnel, 4½ miles long, carries the lines for Wales below the bed of the river.

WALES

Much of Wales consists of mountains over 2,000 ft. high, with the longer slope and longer rivers to the east, and the short slope and shorter rivers to the west. North Wales is higher, bleaker, more picturesque, and more thinly peopled than South Wales, where the lowlands are more extensive, and coal and iron are abundant.

North Wales. North Wales consists of the counties of Anglesey, Carnarvon, Denbigh, Flint, Merioneth, and Montgomery, nearly all rugged. In the north-west Snowdon rises to over 3,500 ft., with magnificent precipice, lake and valley scenery. The Conway valley, with Conway, and the fertile Vale of Clwyd, with Rhyl, open to the northern lowland. Between the two is Llandudno, crowded with visitors in summer. The lowland is broadest in the island of Anglesey, separated from the mainland by Menai Strait, crossed by a tubular bridge, with Bangor and Beaumaris on opposite sides of the strait. Holyhead, on Holy Island, west of Anglesey, is the mail-packet station for Ireland.

The Dee Valley. An important break in the mountains of North Wales is made by the Dee, which rises among mountains just under 3,000 ft., not far from Bala Lake, the largest in Wales. It opens to the Flint lowland, with the collieries of Ruabon and Wrexham, and leads to the English Border at Chester, not far from the head of the estuary, which commands the route to the English plain, and has been important since Roman times. Its ancient streets, with their covered arcades, and its mediæval walls and towers, preserve for us a typical Old English city.

The West Coast. Here we find the familiar occupations of fishing and the summer tourist industry carried on by Aberystwith, and many other towns, each at the mouth of a picturesque valley opening to the sea. The same type continues along the South Wales coast. Summer brings prosperity, the winter usually privation, and much loss of life in the south-westerly gales.

South Wales. South Wales consists of Cardigan, Pembroke, Carmarthen, Glamorgan, Brecknock, and Radnor. The highest parts are in Cardigan, where Plynlimmon separates the Severn and Wye from the rivers flowing east and south, and in Radnor and Brecknock, where the mountains rise to over 2,000 ft. On the west coast are Cardigan, at the mouth of the Teifi valley, and Fishguard, which trades with the opposite coast of Ireland, and will soon become an important packet station.

A broad lowland fringes the south coast, treeless in the west, where it fronts the Atlantic gales, but rich and fertile in the Vale of Glamorgan. The coast is deeply cut into bays, the finest harbour being Milford Haven, on which is Pembroke, with dockyards, and New Milford, whence the South Irish mail steamers start at present. Long, parallel valleys descend to the coast of the Bristol Channel; the Tawe, with Swansea; the Neath, with Neath; the Taff, with Cardiff, and others. In the west sheep-farming is the chief occupation, but in Glamorgan the valleys are alive with colliery and furnace. The South Wales coal is specially good for smelting and for steam coal, and immense quantities are exported, much for naval purposes, from Llanelly, Swansea, Cardiff, Barry, and smaller ports. Iron is abundant, but of poor quality, and the great ironworks of Merthyr Tydvil, and the copper works of Swansea, are largely fed by imported ore brought to the ports at the valley mouths.

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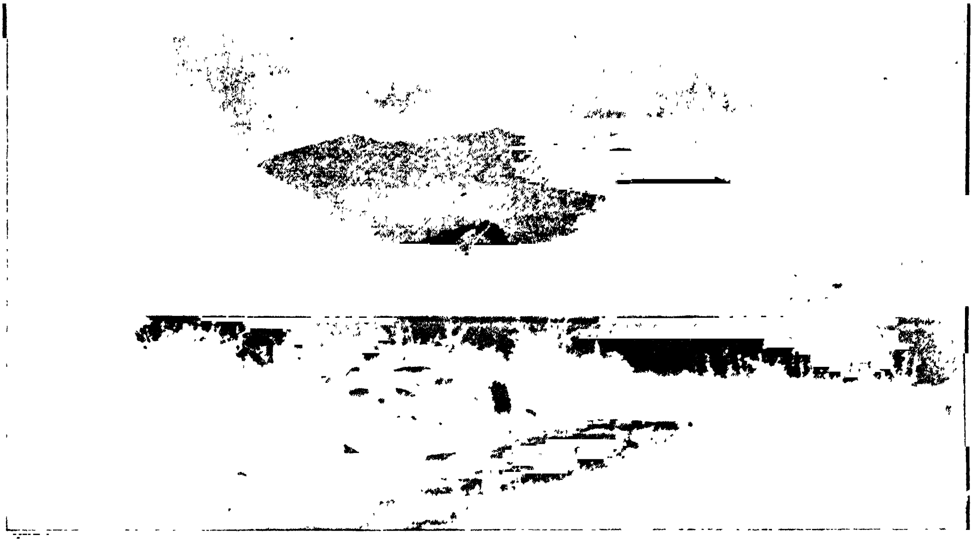


75. SNOWDON FROM NANTLLE LAKE

Frith & Co.

Group 4
BUILDING
9

Continued from page 1176

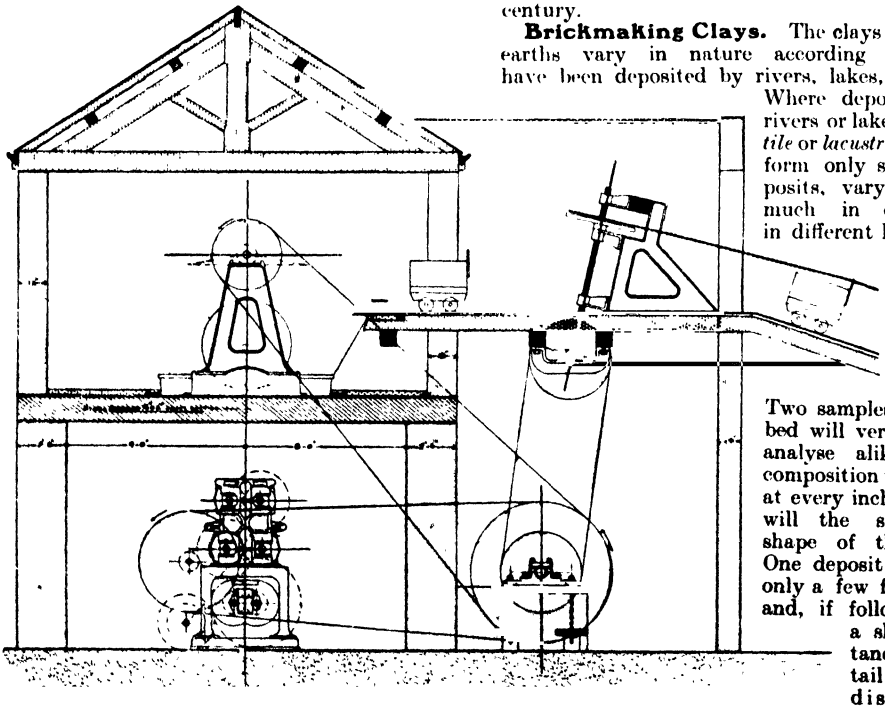
BRICKMAKING

Clays and Clay Deposits. Iron and Brick Colours. Brickmaking by Hand and Machine. Fire Clay and Fire Bricks

By CLAYTON BEADLE and HENRY P. STEVENS

THE origin of the art of brickmaking dates back to remote ages, and is, indeed, one of the very oldest of the crafts. Any plastic earth which can be moulded and sun-dried or baked may be made into a brick. In all probability the first bricks made were only sun dried, although among the earliest ruins of Egypt and Chaldæa may be found not only the sun-dried but also the properly burnt bricks. Herodotus tells us that the walls of Babylon were built of bricks made from clay dug from the trenches, and in Mesopotamia there are enormous mounds, all that remains of brick-built cities. If these bricks be examined it will be found that the outer layers are usually burnt bricks, while those on the inner side of the walls, where they would not be subject to the action of water, were made of sun-dried bricks. Many of these bricks were covered with stucco to protect them. Of course, sun-dried bricks were much more easily destroyed than those properly baked—indeed, we may read in ancient history that towns have been captured by invading armies who diverted a stream to run around the walls, which, being made of sun-dried bricks, were soon washed away. Although in Egypt most of the temples were built of granite or similar rocks, bricks were very much used for many of the buildings, and there still stand brick Pyramids, such as that of Sakkarah. The Biblical stories of the Children of Israel forced to make bricks are well known to all. These bricks seem to have been sun-dried bricks, and were moulded from material made by throwing cut straw, mud, and water into a pit and treading until sufficiently well "pugged."

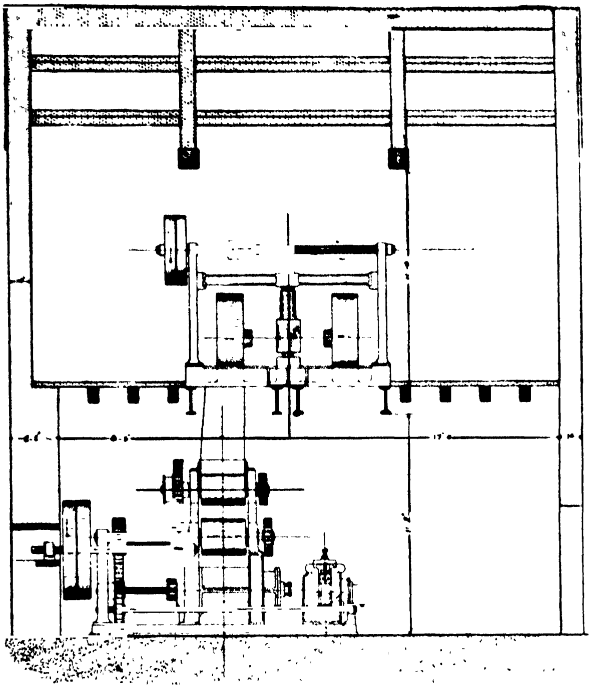
Another example of the use of a mixture of burnt and unburnt bricks is to be found in the Great Wall of China, and in Spain the sun-dried brick is often used at the present day. The Romans were probably the first to burn bricks in kilns, and the art seems to have been lost, at any rate in this country, as no trace of brick buildings is to be found between the time of the occupation of the Romans and the thirteenth century.



1. JOHNSON'S PLASTIC BRICKMAKING MACHINERY: LONGITUDINAL SECTION

Brickmaking Clays. The clays or brick earths vary in nature according as they have been deposited by rivers, lakes, or seas. Where deposited by rivers or lakes (*fluviatile* or *lacustrine*), they form only small deposits, varying very much in character in different localities. Take, for instance, brickfields in any part of Surrey or Kent. Two samples from a bed will very seldom analyse alike; the composition will vary at every inch, and so will the size and shape of the beds. One deposit may be only a few feet deep and, if followed for a short distance, will tail off and disappear; while another, which is scarcely noticeable, will broaden out into a deep bed. The Reading brick clay area is an example of lacustrine deposit. The marine deposits are notable for their great depths and uniformity, brought about by the uniform and regular action of the sea.

The big clay deposit in the Midlands known as the Oxford clay, and so much used for bricks in the neighbourhood of Peterborough, is a marine deposit. Analyses of the clay, taken at varying depths, all show much the same figures, and the extension of this deposit, which crops up again in France, scarcely varies from that dug in England. It will be readily understood that the marine clays are treated for brickmaking on quite different lines from the South of England clays, which are of fluviatile or lacustrine origin—*i.e.*, deposited by the agency of rivers or lakes. In the former case, powerful plant and big machinery are employed. The clay varies so little that it may be taken out for brickmaking with the certainty that, once having secured the right conditions, it will always give the same excellent results. On the other hand, in the South of England small hand machinery is better adapted to work the deposits, which have to be dug and carefully mixed, so as to get the desirable consistency.

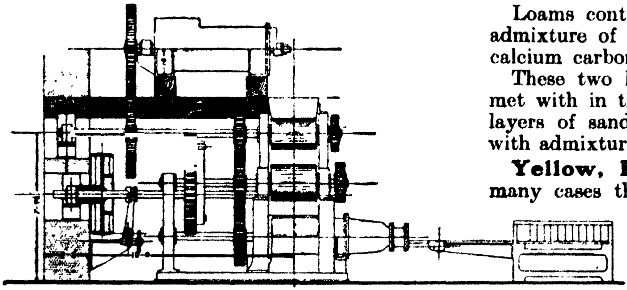


2. JOHNSON'S PLASTIC BRICKMAKING MACHINERY: TRANSVERSE SECTION

Classification of Clays. Clays can be roughly classified into plastic, or strong clays, loams, or mild clays, and marles, or calcareous clays.

In the first class, among the plastic, or strong clays, we may put the purer clays, although the purest of them all, kaolin, or china clay, is never so plastic as some of the others. The Oxford clay belongs to this type. It has, however, some disadvantages, as it contains much sulphur, in the form of iron pyrites.

In the course of burning the bricks, sulphurous fumes are given off in large quantity, and tend to bring about the formation of sulphuric acid. This has a tendency to *weather* out of the brick, causing the latter to go to pieces. The corrosive action of the sulphurous fumes is very noticeable in its effect on the chimney stacks which create the draught in the kilns. The acid attacks the mortar between the bricks, and in the Peterborough district the stacks are constantly under repair. We examined some bricks from within twenty feet of the top of a stack; they were intact, although the mortar was reduced to slime.



3. BRICKMAKING MACHINE FOR "WIRE-CUT" BRICKS

The strong class of clays are often improved by judicious admixture with other substances. Generally speaking, brickmaking clays are composed of other materials in addition to the silicate of alumina, or true clay substance. They contain oxides and phosphates of iron, and occasionally organic matter, iron pyrites, etc. The organic matter is the residue of the putrefaction of extinct vegetable and animal life.

Loams contain, besides the clay proper, an admixture of sand, while the marles contain calcium carbonate, or chalk.

These two latter clays are more commonly met with in the South of England, often thin layers of sand and clay occurring alternately with admixtures of the two.

Yellow, Red, and Blue Bricks. In many cases the colour of a brick affects the selling price more than anything else—especially where a brick is required for facing—with the result that colour often takes precedence to soundness.

Now, the whole range of colour in bricks is due almost entirely to iron, in some form or other. If a clay, consisting of more or less pure silicate of alumina, contains 1 per cent. or less of iron, the burnt brick will be white. As the proportion of iron increases, the colour will pass from yellow to orange, and then to red. With 5 or 6 per cent. of oxide of iron, a good deep red will be obtained. With larger proportions of iron, the colour is still deeper.

The colour is also better developed by stronger firing. If the brick will stand it, and there be enough iron, the colour of the brick will pass from red to blue, and even to brown or black. The Staffordshire blue bricks, so much used for engineering work, are well-known examples of the case in point.

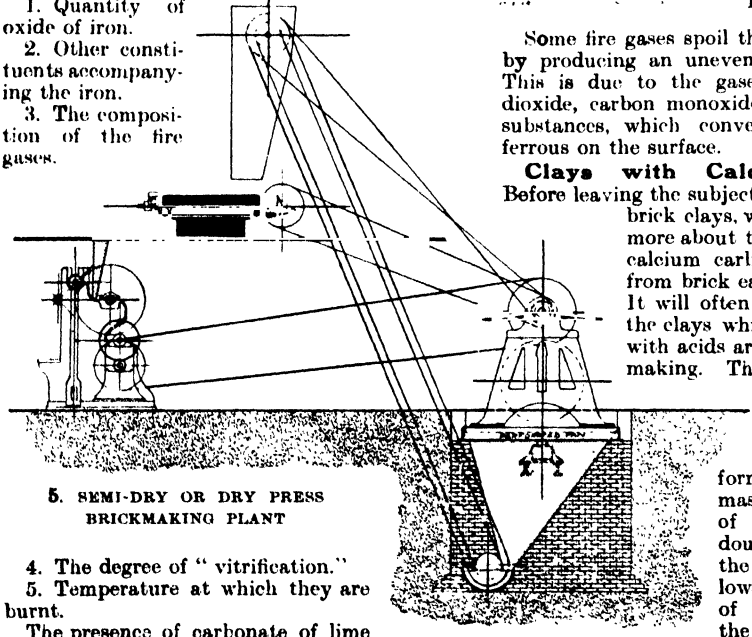
Manganese, a metal allied to iron, also affects the colour of the brick, producing a brown shade, but the proportion of manganese in the clay is so small that it can usually be left out of account.

Modification of Colour. The colour is also much modified by the presence of carbonates of lime and magnesia, and the condition in which the iron itself is present will also affect the colour, so that a knowledge of the percentage of iron in a sample of clay will not indicate accurately what colour the burnt brick will be.

A reference to the course on CHEMISTRY will show that iron, in the chemical sense, may be in either the ferrous, or the ferric state. It is in the latter form that it colours the brick.

The most important factors which affect the colour of a brick have been summed up by the German chemist Seger, who made a life study of clays and their use in making bricks and porcelain. They are

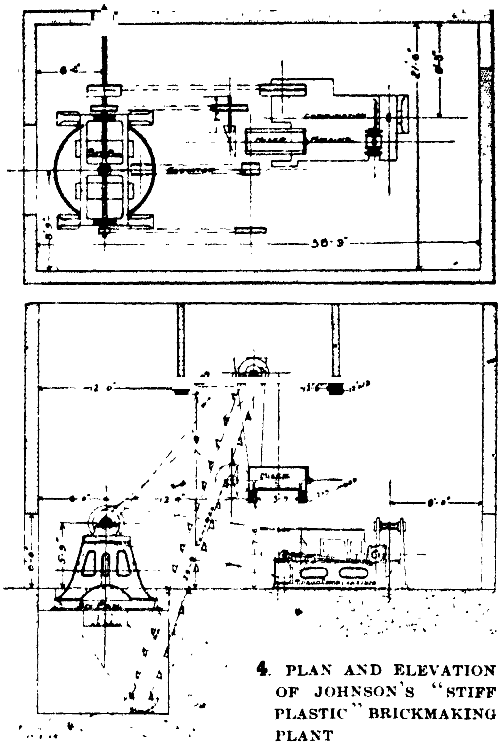
1. Quantity of oxide of iron.
2. Other constituents accompanying the iron.
3. The composition of the fire gases.



5. SEMI-DRY OR DRY PRESS BRICKMAKING PLANT

4. The degree of "vitrification."
5. Temperature at which they are burnt.

The presence of carbonate of lime *bleaches* the colour of bricks, and they burn to a yellow tone, as, for instance, in the case of the well-known London *stocks*. Three per cent. of chalk will neutralise 1 per cent. of iron, and give a yellow instead of a red brick.



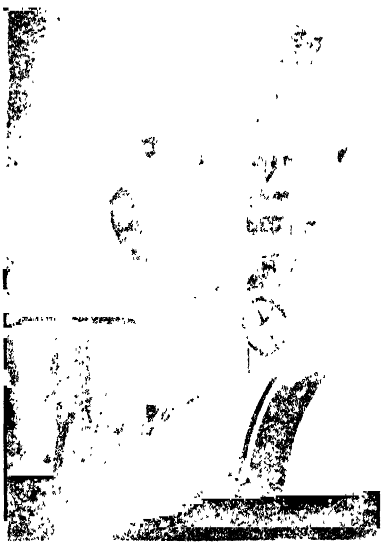
4. PLAN AND ELEVATION OF JOHNSON'S "STIFF PLASTIC" BRICKMAKING PLANT

Some fire gases spoil the colour of the brick, by producing an uneven, mottled appearance. This is due to the gases containing sulphur dioxide, carbon monoxide, and other reducing substances, which convert the ferric iron to ferrous on the surface.

Clays with Calcium Carbonate. Before leaving the subject of the composition of brick clays, we must say something more about the effect produced by calcium carbonate on bricks made from brick earths which contain it. It will often be found stated that the clays which effervesce strongly with acids are unsuitable for brickmaking. This is not always the case ; at all events, if the calcium carbonate is finely divided and distributed uniformly throughout the mass. Lumps, or nodules, of limestone are undoubtedly harmful. As the calcium carbonate lowers the melting point of the clay, it promotes the slight amount of vitrification or fusion necessary in making a sound brick. Twenty-five per cent. of calcium carbonate may be allowed if the brick be well burnt. Such clays can be worked into a bar for hand brickmaking, with 20 to

24 per cent. of water reckoned on the weight of dry substance, whereas the strong clays, free from lime, require 25 to 30 per cent. of water. These points have to be taken into consideration when working the clay in the pug mill. In the process of burning, calcareous clays give off carbon dioxide, which modifies the structure or nature of the brick to a considerable extent, as the escaping gas leaves the brick full of tiny holes, and makes it more porous. In many cases, such a brick will stand the weather much better than a dense, smooth brick. Water which may permeate into the interstices will in cold weather do little harm when it expands on freezing [see PHYSICS], while with a close, hard brick there are still innumerable minute cracks and fissures which absorb water readily, so that when a frost comes the water freezes and rapidly disintegrates the brick.

Hand-made Bricks. This is carried on mostly in the South of England, and is suited to the small deposits of varying composition.



6. SEMI-PLASTIC BRICKMAKING PRESS

Clays are first dug and, if too strong, are mixed with the right proportion of sand or poorer clays by heaping them in layers one on the top of the other. When carted away to be worked up, the men are careful to dig through all the layers, and cart away the different ingredients in the right proportions. If the clay contain flints, chalk, or pieces of rock, it has to be washed. For this purpose, it was formerly the custom to dig a hole 3 ft. deep, termed a *wash back*, or *pan*. The clay was washed out of the mass into this pan, with sufficient water, and left to itself long enough to allow the clay to settle. The water was drained off, and the material dug out. Nowadays modern mills are provided with washing pans having the form of a circular trough. Revolving arms are fixed to a vertical staff in the middle of the trough, and carry harrows suspended by chains. When they are driven round, the harrows churn up the mass of water and clay, which is run off, leaving the deposit of stones, unbroken lumps, etc., on the bottom. The general principle, however, is exactly the same as in the old-fashioned pits. [See also CEMENT.]

Weathering and Tempering. Before the clay is mixed with water, or *tempered*, as it is termed, it is allowed to *weather*, by exposing it to the air. This weathering is of the utmost importance where hand-made bricks are manufactured and where the machinery is not sufficiently powerful to break down lumps of hard rock into which water will not penetrate. Frosty weather is best suited for weathering, owing to the small quantities of water which permeate the crevices, expanding and splitting the stone when frozen. The weathered clay is carted to the pug mill, where it is mixed with the right quantity of water and ground to a uniform pasty mass, or *pugged*.

The old pug mills consisted of pits sunk into the ground in which the clay was stirred up by a revolving arm worked by a sleepy old horse. In a modern pug mill, the motive power is derived from an engine. The mill consists of a large pan in which revolves a vertical shaft, fitted with two horizontal knives. In the bottom of the pan is an opening for letting out the pugged clay, and there is a scraper at the bottom of the shaft for emptying.

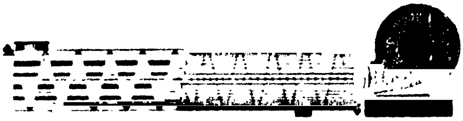
When the clay is sufficiently pugged, it is ready for *moulding*. This used to be done in hand moulds of iron or wood, but modern machines have largely taken the place of such primitive plant [see **11**]. However, owing to the cost of transporting bricks, and the fact that in the South of England small quantities of suitable clay crop up in numerous parts where the installation of expensive machinery would not pay, large quantities of crude, hand-made bricks are still produced.

Wire-cut Bricks. In modern plants the clay is fed between powerful steel rollers, placed directly over the pug mill, which is often arranged horizontally.

The plant in the illustrations [**1**, **2**, and **3**] for working on this system is constructed by Messrs. Wm. Johnson & Sons, of Leeds. On the extreme right-hand side may be seen one of the trolleys in which the clay is brought up from the pit. It runs on rails which slope down to that part of the pit where the clay is being worked. When the trolley is full, it is drawn up by an endless chain, passing round a pulley, seen on the right-hand side of the drawing. The clay is tipped, generally by an automatic arrangement, into the pan, of a type of edge runner, termed a tempering pan. The pan is made to revolve by suitable cogs, and the clay is ground by the heavy rollers seen on the upper floor in **2**, where the plant is shown in transverse section. The clay passes through small holes in the bottom of the pan, and is delivered to the rollers shown on the ground floor, which crush all stones, and the clay passes thence into the pug mill, where it is formed into a column or bar by the expression rollers. The bar is delivered on to a table, on which is a frame provided with a number of vertical steel wires, which can be moved horizontally by means of a lever. By this means the wires are driven through the bar of clay, cutting it up into separate bricks, exactly as in a soap-cutting frame, or when a grocer cuts cheese with a wire. The cutting table is seen diagrammatically on the right-hand side of 3; on the left-hand side are the mixer and crushing rolls.

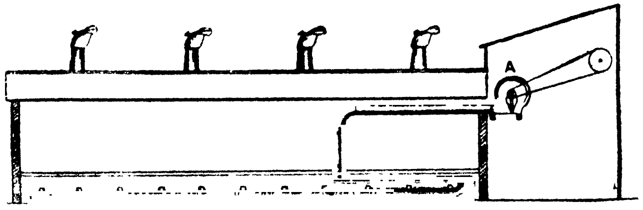
Another System. Another arrangement, due to Messrs. Whittaker & Co., Ltd., for the production of wire-cut bricks is worked on the following system.

The clay is delivered into the grinding mill. This consists of two heavy steel rollers resting on a pan, the bottom of which is made up in sections consisting of steel plates provided with small perforations up to ¼ in. in diameter, and the whole pan revolves, being actuated by the cogwheel above. This plant is similar in construction to Messrs. Johnson's plant as shown in the figures.



7. ROBINSON'S AIR-HEATER AND FAN

The clay is effectively ground, and when small enough passes through the holes into the plate and collects in a pit, from whence it is carried up by the elevator to a screen This consists of a sloping box with a bottom composed of a number of piano wires stretched lengthways. The clay which passes between the wires is conducted into the mixer, while the *tailings*, or larger unreduced lumps, pass over and are returned into the grinding mill. In the mixer the water is added, and the clay worked up to a plastic mass. The mass is delivered into the pug mill, where, after treatment, it is thrust out on to the cutting table, and divided into bricks as already explained. The green bricks by this process have to be dried before they can be put into the kiln. Where possible, this is got over by working the clay semi-dry [5], or by the so-called semi-plastic [4] process.



8. ROBINSON'S HOT-AIR CHAMBER FOR DRYING BRICKS

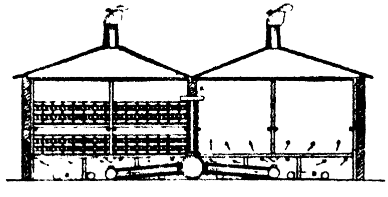
Machine-moulded Bricks. The pits from which the clay is dug are often very extensive — huge excavations in the earth, sometimes 200 ft. deep. The pit slants gently downwards from the machine house, where the bricks are made, and a number of narrow-gauged trolley lines run down to the bottom of the pit or *clay hole*. The *tubs* or small waggons into which the clay is loaded at the bottom of the pit are hauled up by endless chains worked by a pulley connected with the main shafting. When they arrive at the top of the gradient, the clay is tipped out by an automatic arrangement. As fast as the waggons are emptied, they are run down again into the pit to be filled afresh. The workmen dig at the side or bottom of the pit, and occasionally loosen the clay by firing small quantities of gunpowder at the bottom of bore holes.

As the pit is enlarged, care must be taken to remove the earth and soil round the top, so that it does not fall in and contaminate the clay. A good deal of trouble is sometimes experienced by the entrance of water, which must be pumped out when necessary. Indeed, it is almost impossible to continue working during very wet weather.

The clay is first taken to the grinding mill [see 4], a little water being sometimes added to it. The construction of the grinding mill has already been described. The clay is worked so dry that it falls to powder in the hand. As before, it falls through the perforated pan of the grinding mill and is carried up by an elevator, whence it passes through the piano wire screens, and thence to the press. The clay is fed into the mould of the brickmaking machine proper, where it is kept hot by steam. The clay, in a semi-dry condition, is subjected by powerful levers to a pressure of several tons. A brickmaking press is shown in 6.

All sorts of waste materials can be used for making bricks, such as stone chippings, clinker, slate refuse, blast furnace slag, or sand, reduced to a suitably fine powder by powerful machinery, and *bonded* with lime or cement.

The compressed brick is automatically delivered to a table. Sometimes as much as 80 tons pressure is put on the brick, and, although the material was quite powdery as fed into the press, it is now compressed into a solid brick [6], which holds together sufficiently to be handled, and can be put direct into the kiln without previous drying; whereas bricks prepared by the plastic process require to be dried before they can be put into the kiln.

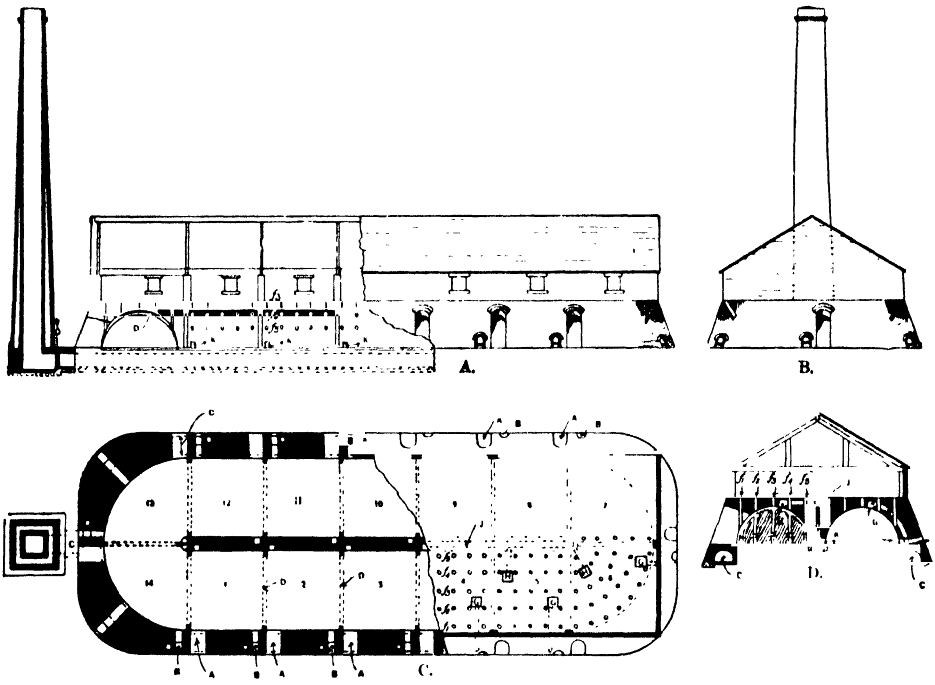


9. DOUBLE-CHAMBER SYSTEM OF BRICK DRYING

Brick Drying. This drying process used always to be carried out in the air, the bricks being piled upon each other in rows, in such a way as to be exposed to the air as much as possible, and covered with a screen or roof to keep off the direct heat of the sun. If fully exposed to the sun they would dry too rapidly, and would almost certainly crack. There is a tendency, however, to replace drying in the open by special drying-rooms, one form of which, constructed by E. Robinson, we may now describe.

In the heater [7], the main feature is the spiral *diaphragm*. Steam is admitted inside the parallel system of tubes, and the wind, driven in by the fan, circulates through them, and travels about four times the outside length of the cylinders. The effect of this is to give a very high efficiency, and a large volume of air can thus be heated to 250° F., or higher, if required. Either live or exhaust steam can be used. If the former, a steam trap is connected, so that only the steam actually condensed is used.

A medium-sized heater of this kind is about 12 feet long by 2 ft. in diameter, and its air inlet and outlet are attached to suit any desired position. Here it is placed under a floor, as illustrated in 8 and 9.



10. OSMAN'S MODIFICATION OF THE HOFFMAN KILN
A. Longitudinal elevation and section. B. End elevation. C. Plan. D. Transverse section

For drying bricks in a long, narrow room, as in 8, a trunk blast-pipe is carried from the heater along the centre, under the floor. This pipe is provided with a series of orifices, so proportioned as to disperse a blast of wind uniformly throughout the whole length of the building. A board of triangular shape is arranged over the discharging orifices, as seen in 9, and the arrows indicate the way in which the blast is dispersed.

Use of Double Chamber. It will be seen that in the arrangement illustrated in 9 a pair of rooms are built side by side, with a heater standing under the partition between them. The fan, not shown here, would be fixed at A [8]. It is represented as viewed from one side. From either side of the heater there is a branch pipe which is carried along the centre of each room. Thus the heater has a separate blast connection into both rooms, and by means of a blast gate on each side the current of wind may be entirely shut off from one room and the whole of it turned into the other room. This construction has the advantage that one heater and fan serves for two rooms, one of which can be cooled down, cleared and refilled, whilst the drying process is going on in the other room.

In one of the rooms [9], a double tier of bricks is seen stacked. The upper tier rests upon shelves of open latticed woodwork. These are readily removed and replaced for clearing or stacking. At B are shown steam-pipes for supplementary heating.

This system of drying applies to wire-cut and such bricks as are handled in the way indicated. It will be understood, however, that this apparatus is equally adapted for what is known as the progressive, or *A B C* mode of working, where the bricks are stacked on cars and run into the dryer on rails. In the latter case it is necessary to excavate the ground, putting all heating appliances below, and leaving a level surface for the car track. It is generally necessary to supplement any blast system of brick-drying with some steam-pipes under the floor. These are shown at B in 9. As a rule motive power for driving the fan is only available in the day time, and it is necessary to maintain some heat. The two independent systems are very convenient for utilising exhaust steam, and when this is turned into the pipes, very little live steam in the blast heater will be sufficient to ensure drying as rapidly as most clays will stand without cracking. By running the fan only during the day, and by allowing the room to cool down at night, bricks of the most delicate clay can be rapidly dried without cracking.

The Sturtevant System. Under ordinary circumstances, a good deal of heat must be left in the kiln gases in order to produce sufficient draught in the chimney. This is economised by the Sturtevant system, which draws these hot gases through drying chambers or tunnels in which the bricks are placed. The induced draught is produced by means of a fan. So constructed, there is no need to build a chimney stack, as the fan creates the necessary draught and has the advantage of being easily regulated. The method is arranged to suit the type of brick. If the latter are very soft they will dry on the floor of the chambers, but it is usually preferable to place them on the shelves of trucks which are run into the tunnels, the hot air passing through lengthways. Some bricks require drying very slowly, while with others the drying may be forced.

11. HAND-BRICK MACHINE

Brick Burning. The old method of burning bricks in stacks in the open without any proper kiln, is still largely practised, especially where, in order to meet local requirements, building operations are proceeding on the spot, and the clay deposit is only a small one. The green or unburnt bricks will usually be those made by hand. They are built up into a stack, or pile, with layers of fine coal between layers of bricks. A hole is left near the bottom for firing, and spaces are left to form air-holes and produce the necessary draught. As many as 50,000 bricks can be burnt in one operation. The heaps should be protected from prevalent winds by luting the crevices with clay or placing hurdles thatched with straw against the sides.

The burning takes several days, and the hot gases and flames find their way through the crevices and air-holes, eventually escaping at the top of the heap. As might be expected in such a primitive arrangement, many of the bricks are very unevenly burnt. The temperature on the inside is much higher than necessary, and there bricks are sometimes over-burnt; while on the outside they are not sufficiently heated and are under-burnt.

Burning in kilns is an improvement upon this method. The first kilns were of simple construction, and intermittent in their action—that is to say, when the bricks were burnt the kiln was allowed to cool down, the burnt bricks drawn and replaced by fresh green bricks. As the kiln could not be entered until it had cooled down, most of the heat given off by the cooling bricks was lost.

Modern kilns are built on the continuous principle—that is to say, the heat given off during burning and cooling serves to drive out moisture and give the preliminary heating to the green bricks. The original continuous kiln was invented by Hoffmann, and the first kiln in this country is said to have been erected at Roundwood Brick Works, near Wakefield, where it is still in use. A modern form of this kiln, as modified by Osman, is shown in the diagram [10].

The Modern Kiln. In principle it consists of an oval framework, roofed in and divided by a centre partition, forming a continuous tunnel, separated into chambers, usually seven or eight on each side, in which the bricks are burnt. The fire travels continuously round these tunnels, and when the heat is at a maximum in, say, chamber 2, the opposite chamber, 9, will be cold. The heat produced in chamber 2, passing on through chambers 3 and 4, etc., heats these in turn; and when the fire has travelled round sufficiently far, chamber 2 will have cooled sufficiently for the burnt bricks to be taken out and replaced by green ones.

The draught is produced by the chimney, but the escaping gases have given up most of their heat in drying and burning the bricks, so that they have cooled to a temperature of 150 to 200° F. before they reach the chimney. The great economy effected will be evident, as none of the heat is lost, and only enough left in the escaping gases to produce the necessary draught.

The fuel is fed into the kiln through small holes, termed *feeding holes*, situated in the arched roof. These are seen at f_1 to f_5 [10], C and D.

The fine coal, or slack, used drops down spaces or pockets left in the bricks as stacked in the chamber underneath. Care is also taken to pile the bricks with spaces between them, so as to allow for the necessary draught; and they are usually arranged in *blades*, or loosely built walls, about 1 in. apart, with spaces about 2 in. wide, termed *traces*, running longitudinally, to take the draught through the bricks.

The Osman Kiln. The Osman kiln shown [10] consists of fourteen chambers. Each chamber has a doorway (A), termed a wicket, through which the bricks are taken when setting or drawing. Each chamber is also provided with what is termed a damper-opening (B), which conveys the draught through the chamber to the main flue (C), running round the kiln under the outside wall, and connected with the chimney. The walls separating the chambers are often temporary, and contain holes corresponding to the traces. As the heat of the chambers is drawn forward it passes through these openings into the next chamber.

Supposing that fire is burning, say, in chamber 1, chambers 2, 3, 4, and 5 may be filled with the green bricks. The dampers corresponding to these chambers will be closed, while 5 will be open, so that the hot gases from 1, passing through 2, 3, 4, and 5, reach the chimney through the flue (C). To prevent cold air in 6 chamber rushing back and checking the draught at 5 damper, the trace-hole openings in the drop wall of 6 are blocked up by pasting paper over them. This paper will gradually burn away when the heat is sufficiently far advanced. When this happens, the damper of 5 is closed and that of 6 opened. The holes in the wall between 6 and 7 are pasted up as before. In this way the heat gradually advances through the chambers; those in front being continuously filled up with fresh green bricks, while those behind are emptied of burnt bricks as soon as they are cool enough. There is an outlet (G) from each chamber, so that the steam gradually driven off from the green bricks is taken from the chamber at the top and drawn into the main flue and away to the chimney. This steam, if allowed to pass through the chambers ahead, would condense on the green bricks, causing them to soften and crush, and would also affect the colour of the brick. It is necessary to draw off this moisture slowly and gently, so as not to crack the green bricks; and to effect this the waste heat through the cooling chambers is drawn upwards through the outlet H, and along a branch flue which joins the central hot air flue at J. The heated air is thence carried down into the chambers at K, containing green bricks, in advance of those actually burnt. The moisture driven off leaves at the point G, reaching the main flue C. When the bricks are taken out they are ready for use.

Fire-clays and Fire-bricks. Such bricks fuse at a very high temperature, and are prepared from special heat-resisting clays. They will stand temperatures at which ordinary bricks would melt and flow like water. Many natural clays are found suitable for their manufacture. They usually consist of silica and alumina, but contain very little iron, lime, or alkalies, as the presence of all these substances tends to lower the melting point of the brick.

Many natural fire-clays are worked for making this class of brick. Such clays are obtained from Dowlais, Stourbridge, and other places.

Dinas bricks, made from dinas clay found in Wales, consist almost entirely of silica, and artificial bricks have been prepared on the same lines by mixing silica with about 1 per cent. of lime. *Ganister,* a fire-brick of a highly refractory nature, is used for lining furnaces.

Much of the fire-clay used in this country comes from Stourbridge, but excellent material is also obtained from Northumberland, Lancashire, Warwickshire, and South Wales.

Many fire-clays are found underlying coal seams, and are hence frequently termed *under clay.* They are usually of dark greenish-grey colour, and of dense consistency. They are generally mined in the same manner as coal. When brought to the surface, the clay is spread in even layers, and allowed to remain several months, that it may become thoroughly "weathered," after which it is taken to a wash mill and worked until the mass attains a regular consistency. It is run out into settling backs, and when the water has evaporated, the mass is cut up and moulded.

To give an idea of the chemical composition of fire clays, we append the following analysis of Stourbridge clay:

Silica	65·10
Alumina	22·20
Magnesia	18
Lime	·14
Oxide of iron	1·92
Potash	·18
Phosphoric acid	·06
Water	9·28
Organic matter	·58
	99·64

Good fire-bricks may be made from the refuse of china clay and quartz sand. Such bricks will consist almost entirely of silica and alumina, with not much more than 2 per cent. of other ingredients.

How to Measure Temperature of the Kiln. It is often of considerable importance, and of great practical interest, to measure the temperatures of the brick kiln, so as to secure even and regular firing—a great desideratum in practical working. The temperature of the kiln is so high that it is not possible to measure it by ordinary thermometers, and there are a number of special devices which are employed for this purpose. Among these, some of the most sensitive and accurate are constructed to work electrically. Many of them depend on the resistance a wire offers to electric current, as the higher the temperature the greater the resistance; but for brickmaking and allied industries simpler contrivances are often used, as, for instance, the Seger cone, which depends for its action on the expansion of a piece of fire-brick when it gets heated in the kiln.

Another appliance is the Watkin Heat Recorder. It is simply a block of very refractory ware, with five recesses or shallow cavities sunk into its top face, in which are placed small pellets of varying fusibility, and of definite composition and melting points. The actual temperature expressed in degrees on the Centigrade and Fahrenheit scales is given in the tables used with the recorders.

They are provided with a special wrapper, which serves to retain the loose pellets in their places, and which is not removed before firing, as it readily burns away. After firing, it does not matter if the loose pellets drop out, as those pieces which fuse will always remain attached to the recorders, and from these the temperatures are read.

Brickmaking concluded

Continued from page 1156

NEW WORK IN OLD FIELDS

Unworked Corners in Old Fields for the Inventor and Scientist. A New Educational Factor. Modern Photography. The Scientific Farmer

By ERNEST A. BRYANT

WITH this article, one aspect of the present course attains finality. Highly important considerations, to which all that has so far appeared under this heading serves as introduction, remain to be reviewed. Succeeding articles in the same course have for their object the inculcation of methods whereby the student, whether his goal be literature, art, science or industry, may seek and win inspiration, and, having gained that inspiration, turn it to practical account in the pursuit to which he shall devote himself. The moral and intellectual development of a man is, of course, as ardently to be sought as that merely mechanical genius into which a well-schooled savage might develop. The character and career of an Edison are greatly to be commended to the study of youth with ambition. They are an inspiration to the zealous, an example to the able, a reproof to the lethargic. But a man's library must not be all Edison ; he must have his Emerson and his Shakespeare ; he must have thought not less than thews, morals as well as muscles. Thomas Brassey could never have provided half the world with railways had he been simply a skilled contractor and engineer.

Character an Asset. Character was as considerable an asset in his gigantic success as the ability of a born engineer. It was his fine moral fibre as much as anything which made his fame in industry world-wide. Almost for the first time it was insisted, in all he did, that work should be honest ; that every engagement entered into should be carried out with the nicest observance of moral as well as legal obligation. Every day, for many years, 75,000 men, far scattered over the world, worked upon his enterprises. Every man of those 75,000 knew that while he could rely upon his master as upon the unfailing rotation of the seasons, each in his individual capacity, no matter how responsible, no matter how insignificant, knew that he was expected to render an honest account for each day's labour. Character, equally with capital and energy and genius, built the railways upon which the fame of this noble Englishman was reared. The earnest student will read and value the articles which follow on this aspect of self-development—the development of character and of mental energy.

There still remain some schemes yet to be mentioned. No pretence is made even to have approximately exhausted the subject. No man's brain could do more than evolve suggestions sufficient to more than touch the fringe of the subject. Probably every reader of the course will be able to suggest a dozen new ideas from each of those contained herein. As has so often been shown, an idea for a specific industry finds acceptance in a totally unexpected quarter. The man who essays the solution of cotton for the making of artificial silk finds a product for the manufacture of incandescent mantles ; while the maker of a new form of metal fencing proves to have the very idea needed for the builder who relies for his walls and floors upon reinforced cement. From a leaf springs the design for the Crystal Palace ; from the boring of a destructive worm the secret for man's sub-aqueous tunnelling ; from the refuse of the coalpit medicine to cure half the ills to which flesh is heir, perfumes to charm the senses, disinfectants to preserve him in health, essences and flavourings to delight his palate. It would be idle to preach to a colliery proprietor or a gas-works owner of the chemical properties of the substance which he handles ; but the story told to the student of chemistry means much to him and mankind, whom he is to benefit.

Cheap Telephones. A business man of standing was asked in what direction he would wish to see progress sought in so simple a matter as office equipment, in time-saving apparatus for a great concern such as that of which he is the head. He did not see any particular in which present-day methods could be improved. Yet that man, if he wished to see the chief men of his dozen departments, would have to send as many separate messages, wasting his own time while each man was making the journey to his counting-house ; wasting, too, the time of each manager as he came from and returned to his own department. The idea of a general installation of cheap telephones throughout his premises did not appeal to him ; verbal messages carried by a junior clerk had always served, and would serve. Yet, in the absence of the responsible head, work may stand still with scores of his employees. The cheap telephone for communication, department with department, and the office with all, is one of the things of the office, the factory, warehouse, shop, and other business establishments of to-morrow.

Economising Time and Money. In America they have, in all the large hotels, an elaborate system of inter-departmental telephony. If a guest wishes to have his bath prepared, he puts the indicator to the number on a dial and presses a button ; if he wishes a meal brought to his room, or one to be prepared for him elsewhere ; to send a telegram, or book a seat at a theatre or concert ; if he wants a paper or a carriage—no matter what, there is the want indicated on the dial. He applies the indicator to it, presses the button and the rest is done for him. This means a great saving of time to the guest. It is not designed, however, wholly for the convenience of the latter. The wages of domestic servants in the United States are high; it is cheaper, hotel proprietors find, to bear the initial outlay necessary for the installation of this instrument than to employ an unlimited number of messengers to run about from floor to floor and from room to room. This instrument, or something of its character, ought to be in the office of every man who has upon his premises a large number of employees, and needs frequently to be in touch with those responsible for the conduct of the several departments. Time saved is money gained.

The Gleaner's Harvest. The man who will take the trouble to re-explore fields in which he is no longer a pioneer will find a rich harvest for the gleaning. Lord Rayleigh stands in the very foreground of the world's scientists. What has he done? The work which places him, with Lord Kelvin and Sir George Stokes, in the ranks of the greatest physicists of the age, has been well summarised in a couple of sentences: "A great part of his theoretical work consists in re-surveying things supposed to be already known, and elaborating their theory into precision and completeness. In this way he has gone over a great portion of the field of physics, and in many cases has either said the last word for the time being, or else started new and fruitful developments." If our giants can stoop to laborious, painstaking work, which to many a young student would seem humdrum, the youthful worker with ambition and new ideas need not be ashamed to seek the golden grain where men before them have applied the sickle.

Not only may we seek improvements of inventions already before the world. There is profitable return in seeking new applications of those inventions. The cinematograph and kindred mechanisms have been, until quite recently, the toy of the promoter of entertainments. Their use in preserving for posterity historic spectacles of our own day has, of course, been recognised, but their value to science and ordinary education has been overlooked.

A New Educational Factor. Now, however, it is found that the cinematograph may be a most valuable adjunct to the lecture, illustrating scientific processes, surgical operations, and what not. The idea is capable of development in many ways. But there is a considerable barrier in the way of its immediate popular application—the cost is excessive. The films for the negatives now cost, it is found, at the rate of a sovereign for every minute of exposure. That makes the common use of the cinematograph prohibitive. A newer, cheaper substance is sought. When that comes, every school, every lecture-hall, may have its studies of special subjects illustrated by this wonderful handmaid of science. The eye is a wonderful aid to assimilation of knowledge.

A child will learn by ear to utter a sequence of sounds to represent certain ideas, and will repeat such sounds with some pretence at accuracy. If that child be asked to write out what it has learnt the result will be ludicrous. We spell by the eye. In any average company of a dozen persons not six will be able to spell verbally any ordinary word which has a curious spelling. But they will write that word correctly. In doubt as to a spelling, a man instinctively takes up pencil and paper and writes it. If the letters are not set down in conventional order, the eye, that diligent servant, at once detects the mistake, though the ear cannot. The cinematograph would be an invaluable aid to the eye and make instruction more easy and more attractive. But its general application to such methods is commercially impossible until we get cheaper films. The old ground must be gone over again, but more thoroughly.

Doubling the Microscope's Use. Another excellent example of the result of re-exploration comes to hand in a new addition to the functions of the microscope. All these years we have had to be content with having one field of observation at a time. If two objects were to be compared, they must be examined separately. It was infinitely laborious and tedious, and comparison could not be as exact as the careful man would wish. But diligent seekers have been toiling away in the old paths, and seem about to win their reward. A new attachment is being tried which will give the microscopist two fields of observation at once. The old stereoscope used to give us two pictures to form one under the influence of the lens. This new apparatus reverses the process, and enables the two eyes simultaneously to have two fields under microscopic observation. For comparative work this will, of course, be invaluable, and the time saved to the microscopist devoted to work of this character will be practically doubled.

The story of sulphuric acid is another illuminating example. Two processes, both very old, have been in use with but scanty modifications, as well on the Continent as in England. The English method has involved the erection of vast chambers of lead, bound together with a mighty framework of timber, and elevated upon arches of masonry each several feet above the ground. This process has been unwieldy; it has consumed space unnecessarily, and it frequently only succeeded in yielding an acid highly charged with impurities. The circumstances have constituted an insistent call upon the attention of the inventive.

The Call of Necessity. When Queen Victoria came to the throne we looked entirely to Sicily for the supply of sulphur, out of which to manufacture our sulphuric acid. A year after that event, however, the Sicilian Government established a monopoly of the sulphur trade. The result was an immediate and heavy advance in price. Human ingenuity, when put to the test, can generally get round, or over, a wall which it cannot go through; it did in this case. Sicilian sulphur failing, chemists cast about for a new substance, and iron pyrites proved the thing required. Ever since then iron pyrites has encroached upon the preserve of sulphur, and to-day is infinitely more in requisition than the original substance. But there has always been the objection that in it are foreign substances, the most deleterious being arsenical compounds, which render it inapplicable for many purposes.

At last two persevering students in a chemical laboratory have solved the problem. The huge and clumsy chamber is to disappear. A new process has been evolved. By forcing different gases through a tube containing platinum-asbestos, the acid is formed by what the chemist knows as catalytic action. Catalysis is a term in physics full of mystery and fascination, which the student will study in other courses of the SELF-EDUCATOR. Here it operates in a very small apparatus, produces a pure acid, is already commercially worked, and, at a step, foreshadows a complete revolution in the industry. For it is an industry to itself, this making of sulphuric acid. Great quantities are required for the manufacture of soda, for bleaching, for calico-printing and dyeing. The manufacturer finds it indispensable; the chemist requires it for the laboratory; the medical practitioner could not make up his medicines without it. So universal is its use that men have been content to regard the last word as said in its method of production.

The New Photography. The system already described comes under the heading of contact process. A more popular application of the contact process relates to photography. By the new method the photographer runs over his negative a solution of ether containing hydrogen peroxide. Here, again, catalysis operates in its bewilderingly arbitrary way, but all for good. Wherever the silver on the negative is reduced, the hydrogen peroxide is immediately destroyed, but where the silver is not reduced, the hydrogen peroxide is not destroyed. The consequence is that when a negative so treated is brought in contact with sensitised paper it produces practically the same change in that paper which would have resulted from the exposure of the latter to the sun. The sun is no longer necessary for printing-out! To how many thousands of amateur photographers, permitted daily only fragmentary leisure, may this prove a boon. Not only does it save their time; it will tend vastly to save their pockets, for, instead of the costly sensitised papers now employed, a much less expensive one will be possible.

Such is some of the gold from old mines. The latter are far from exhausted. Note the advance in steam-raising which has occurred within the days of men not yet in their prime. A score of years ago the normal pressure for a boiler was about 50 lb. to the square inch. Men have worked steadily at improvements, and to-day the modern installation has 180 lb. pressure to the square inch. Again, twenty years ago, ordinary wet steam was employed, steam just as it came from the boiler. To-day the steam has to be superheated through a temperature of 180 degrees Fahrenheit. At first it was tried as gas, but to-day this superheated steam with the pressure indicated is the steam by which our engines are driven. Yet twenty years ago the engineers thought perfection was expressed in the apparatus then at their disposal.

The Scientific Farmer. There is another field which has not yet been exhaustively exploited—the field over which the dairy farmer is lord. As it has been already pointed out, new methods are sought for the distribution of pure milk in centres of population. We have to deal not with effect but cause; not to lament the sale of milk injurious to health, but to secure that milk shall not become unhealthy in condition before sale. Very rightly the hand of the law descends upon the man who has recourse to "preservatives" so-called. Pasteur gave his time in vain to the study of this question if at this day "Pasteurising" of milk has been forgotten or ignored. By this method milk can be safely kept long enough for its distribution in a sweet and sound condition. Its use is slowly being adopted in England. But the English farmer leaves with reluctance the rut in which his forbears trod. He grumbles at the sale of foreign butter, but refuses to recognise, or at any rate to alter, the fact that his "fresh" butter will not keep. With every desire to encourage the sale of the home-made butter, than which at its best none in the world is better, we all know that the English product is apt all too soon to go rancid. The reason, apparently, is that the maker either does not take the trouble, or has not the means necessary, to eliminate the buttermilk whose "turning" spoils the whole supply of butter. Yet it can be done in this country. The dairy farmer will have to recognise the importance of co-operating so that he can have, in a central part of the area to which he belongs, a "creamery" to which he and his neighbours can send their milk; and there, with the best of plant, have their butter and cheese made, and the good name of the English material re-established.

Ideas Concluded

TRACING AND CUTTING OUT BOYS' SUITS

Continued from p 1113

Drafting Sleeves, Vest and Knickers. Tracing the Pattern. How to Place the Pattern on the Cloth. Cutting Out

By Mrs. W. H. SMITH and AZÊLINE LEWIS

The Sleeve. For this a piece of paper 19 in. by 9 in. is needed; 2 in. down from top and 1 in. in from edge, draw two parallel lines, half the breast measure apart (6½ in.). Letter the corners A and B. C is midway between A and B: C to D, 1 in.; A to E, same distance as J^a to C^a, in Back Draft [**16**, page 1112].

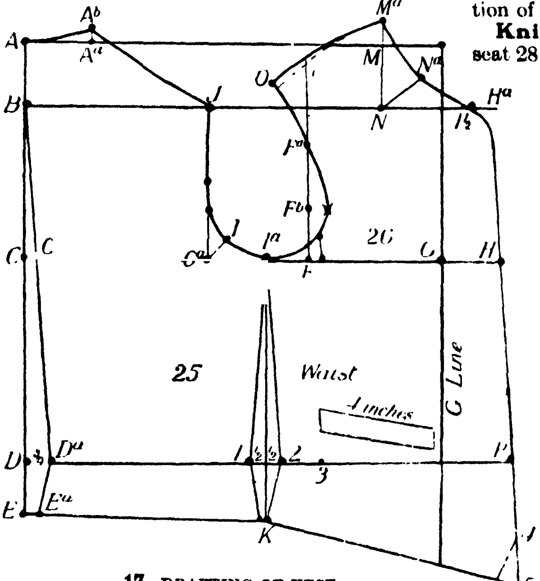
E to F is one-fourth; F to G the same; F to H, ¾ in.; B to I, 1 in.; A to J, length of sleeve, omitting width of back [see broken line, **15**].

Square a line out from J, J to K, 1 in.; K to L, one-third of breast, plus ½ in. M is midway between K and E; square elbow line out from M; M to N, ¾ in. Curve top of sleeve from E, through G and D to B, and from E through H to I. Slightly curve from I to within 2½ in. to elbow line. Curve from E through N to K.

Pockets. 2 in. out and down from 3 draw a line 4½ in. for pocket opening; for position, see diagram. The flap is 1½ in. deep [**15**].

Vest. Working scale half breast (13 in.), half waist (13 in.); ¼ in. turnings are allowed on all seams, but if the cloth is very thick allow ¼ in. extra on fronts.

Drafting the Vest. This method of drafting vests will be found most useful, it being so arranged that it will fit either the smallest or the largest sizes that would be called for [**17**].



17. DRAFTING OF VEST

Begin the drafting as for coat.

A to E, 14 in.; D to E, 1½ in., or length required; D to D^a, ¾ in. Curve from ¼ in. in from E, through D^a to B. Back line to C^a, one-third of breast, plus 1½ in. (5¾ in.), to F, two-thirds (8¾ in.), on to G, half breast; to H, 2 in. more than the measure. G line to H^a, 1½ in.; C^a to I, one-twelfth. I^a is midway between back line and H.

Draw line from I^a, 2 in. below waist line, and make K; 1 and 2 are ½ in. to right and left of line K. Draw lines from K through I. to I^a, also through 2 to same point, and from K to E. Curve from I^a through I to J line. Make a dot ½ in. to right of F, square down to waist line and make 3; 3 to P, half waist (6½ in.), draw line from H through P to bottom of paper; curve from H to within ½ in. of H^a (or lower if desired); continue neck, shoulder, and armhole curves as in **15**.

P to 4, 2 in.; P to 5, 3½ in. Draw line from 5 to K; 5 to 6, ¾ in.; draw line from 6 to 4. K line divides the vest.

The ordinary length of slit, or opening at side, is 2 in.; this should be left in all vests to allow of the expansion of 2 in. which takes place when sitting For position of pocket, see diagram.

Knickers. Waist 26 in., seat 28 in., side length 18 in, inside leg 10 in. Working scale half waist and half seat; ¼ in. turnings are allowed on all seams. First draw a line 2 in. in from edge of paper. 1 to 2, side length (18 in.); 2 to A, inside leg (10 in.). This will leave 8 in. for the rise of body. Square line from A about 10½ in.; A to B, half seat (7 in.); A to C, two-thirds (9½ in.); C to D one-twelfth. B to B^a one-twelfth.

Square line from B, raising the ruler ½ in. above A; if this is omitted the knickers will be too tight in front waist. B to 3, half-seat, plus 1 in.; 3 to 4, 2 in. Draw lines from 3 and 4 to side line; B to E, one-third of seat and 1 in. (5¾ in.); A to F. quarter of seat (3½ in.); E to F^a half seat and 1½ in. [**18**].

The Seat Angle. Draw line from C through E, make G 3 in. up from line 4; spring out ¼ in. and connect to back line; 3 to H, half waist; from back line to I, half waist and 1 in.; back line to J, half waist and ½ in.; 4 to K the same. Draw line across top of seat angle 1½ in. out and down from G.

The Leg. 2 to L, 1 in.; L to M 6½ in., or width round the knee required; draw line from M to C, gradually curve from M to D.

Draw line from L through F^4 and slightly curve through I to J; draw line from J to G; and curve from K through H to A, curving slightly to the right of F. Gradually curve from E through B^a to C, and from E to D.

TRACING THE PATTERN

Either a stiletto or a single tracing-wheel and a stiff sheet of paper are required. Lay the drafting on the paper, and place something heavy on it to prevent its moving.

Front. Trace from 1 through 3 to I^a round the armhole, shoulder, neck curve, front and bottom. Mark pocket openings and inset mark for sleeve ¾ in. up from bust-line on armhole curve. Remove the drafting and cut out the part traced [**15**].

Back. Trace from K through 2 to I and J; from J to A^b; A^b to A, and A to E^a, and along bottom E^a to K. Remove the drafting and cut out. I and I^a must be placed together when making.

Sleeve. Upper part. Trace from K through N, E, G, D, B, and thence down to L, and along to K. Cut out.

Under part. From K through N, E, H, I, O, and L to K, and cut out [**16**].

Vest. Front. This can be simply cut from K through 2 to I^a, and round the armhole, shoulder, neck, and front from 4 to 6 and on to K [**17**].

Back. From K through 1 to I^a, thence to I round armhole, shoulder, and neck, and from A to D^a, and E^a to K.

Knickers. Front. Trace the bottom first from L through M on to C through B^a to 4; from 4 to K, H, and outside F to L [**18**].

Be sure to trace from H to 3 and A to C. Remove the draft, and cut out.

Back. Replace the draft on another piece of paper, trace bottom from L to M, on to D through E to G; then to J through F^a to L. Mark the seat-line from outside A to D and also I and J, as the latter join to K and H in making.

This system of obtaining the pattern from the draft is simplified for beginners; we are not dealing with those who have learned *Tailoring* and *Cutting*. We shall, however, advance as we draft, and make larger garments.

When cutting out the back, remember to add on the triangular piece which has been taken off in the front draft—*i.e.*, from 1 to K.

Placing Pattern on the Cloth. The material should be laid on the table with the fold towards the worker. Press out all creases before laying on the pattern. In every instance the cloth should be tried to ascertain if there is a pile. Place the pattern so that the pile runs from right to left. 1¾ to 2 yd. of 50 or 54 in. cloth will be required [**19**].

The necessary linings and trimmings for boy's suit are as follows:

For Coat and Vest: ⅝ yd. of Italian, or 1¼ yd. of Sateen, 1 yd. Silesia for sleeves and inside lining of vest, ¼ yd. black Silesia for pockets, ¼ yd. black linen, ¾ yd. of canvas, ½ doz. coat and ½ doz. vest buttons to match, a small reel of machine silk for the edges of fronts and cuffs, ¾ yd. of twist, No. 8, and two reels of cotton, Nos. 30 and 36.

For Knickers: Twice their length will be required, and ½ yd. of strong Silesia or pocketing. For the machine, a reel of Knox's fine machine thread, or No. 16 to 24 cotton for the bobbin or shuttle, and No. 30 for the top, ½ doz. large and ½ doz. small buttons, and a packet of tailor's needles, No. 4 to 8.

The pattern should now be outlined with chalk.

Coat. Mark I and I^a, the waist-line on back and front [2 and 3 in **15**], and the pocket-openings. The back is generally placed to the fold. Now mark all round the pattern, leaving an inlay of ¾ of an inch on the shoulder, and just a little from N^a to M^a, also an inlay on the front side seam. Mark the inset for sleeve ¾ in. up from bust-line on armhole curve. The facings must be joined, and should go into the shoulder; they are about 3 in. wide at the bottom. About 1 in. should be left on bottom of coat [**19**] for turn-up or inlay.

Sleeve. It is advisable to leave an inlay of ½ in. on the back seams, and on the bottoms quite 2½ in.

Vest. The fronts only are cut in cloth. Chalk all round the front, also the pocket-opening. The facings should be 1½ in. wide, and taken from seam to shoulder [**19**].

The back is generally made of good black Silesia, and the lining of a light one.

Knickers. In chalking, the pocket facings can be left on, from H to F, and F^a to I, about 1 in. This will save trouble in making.

A good inlay must be left on the back, as from G to D [**18**]. The seat and waist-lines, as from 3 to H, must be marked. It is advisable to leave inlays, or turnings, on the side and inside seams, and from 1½ to 2 in. at the bottom, if cloth permits.

The suit is now ready to cut out and thread-mark.

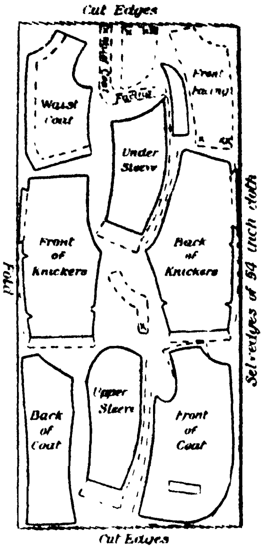
Thread-marking. This is the first operation after the parts are cut out. Beginners should remember that there are two pieces of cloth, and that only one is chalk-marked, the other being outlined by the process about to be described.

Take a No. 5 or 6 needle threaded with double tacking cotton, without knot [see **4**, p. 1111]. Take care to have the stitches as small as possible, and ½ in. apart, round the neck and armhole curves. Having cut the loops between the stitches, cut the threads between the cloth, raising the top piece very carefully, and allowing only sufficient room for the scissors to snip the cotton that holds them together, so that the stitches are not pulled out. When this is finished, each piece will hold the thread-marks, and so indicate the outline of the pattern.

The seams are taken ¼ in. inside the thread-marks, or inturns, the uses of which are evident when any alteration has to be made. Be sure to thread-mark the pockets, also position of buttons and holes.

Back. This must be thread-marked in the same way as the front. It is advisable for beginners to practise thread-marking on two pieces of cloth, as it is an absolute necessity for good tailoring. The sleeves, vest, and knickers are thread-marked on all chalk-marks.

The Pockets. When the various portions are thread-marked, the first process is that of making the pockets. Two pieces of cloth and two of lining are required for the flaps. Cut them ¼ in. longer, and ¾ in. wider, than marked in **15**, then prepare in the following manner.



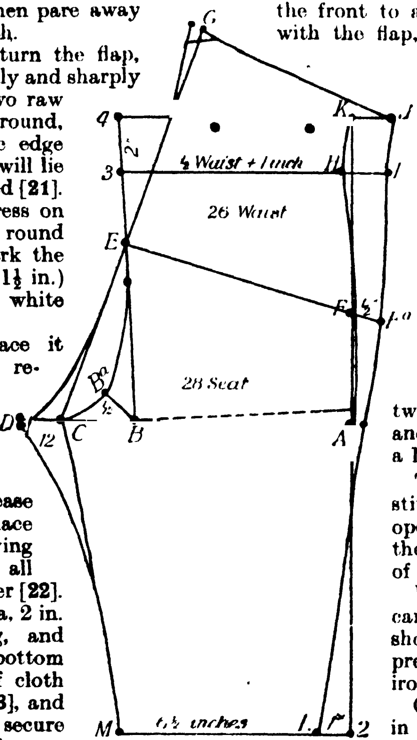
19. ARRANGING PATTERN ON MATERIAL

Baste each piece of cloth on its corresponding lining through the centre to within ⅛ in. of each end [**20**]. Tack round the edge, beginning at the top right-hand corner, keeping the cloth ⅛ in. in from lining, and fulling the cloth on at the corners about 1 in. on either side. This allows it to set flat on the right side, which it would not do if the lining were loose, when the flaps would curl up instead of under. Machine round the edge quite close to the tacking, then pare away the lining even with the cloth.

Take out the tackings; turn the flap, working the corners out evenly and sharply with a bodkin; tack the two raw edges together and baste round, working the cloth over the edge all round, so that the seam will lie ⅛ in. underneath when finished [**21**].

Place a cloth over and press on the wrong side, then machine round 1/16 in. from the edge. Mark the depth of flap (in this case 1½ in.) with a piece of chalk or white cotton.

Take the left front, place it right side uppermost, and re-mark the pocket-opening exactly the same length as flap; turn over, take a strip of strong linen, 2 in. wide and 2 in. longer than the opening, make a crease through the centre, and place this on the thread-marks, leaving 1 in. at either end; baste all round and turn the front over [**22**]. Take a piece of strong Silesia, 2 in. wider than pocket-opening, and long enough to escape the bottom by 1 in.; baste a strip of cloth 1 in. wide along the top [**23**], and stitch along the lower edge to secure the raw edge of cloth to pocket.



18. DRAFTING OF KNICKERS

Now place the top edge (cloth facing underneath) close to the thread-marks of opening, and baste to coat front ¼ in. below the latter [**24**]. Next put the flap on the front, lining uppermost, with the chalk line ⅛ in. above the thread-marks; baste in position, and stitch on chalk-line and along the lower part of opening ⅛ in. from thread-marks [**24**].

Cut along the thread-marks to within ¼ in. of opening, and snip the corners at both ends about ¼ in. on either side to form a V [**25**].

Nick the Silesia at either end to allow the pocket to turn over properly, remove the tackings round the opening, and turn the pocket inside out through the opening; tack along the top, working the two edges evenly together with the finger and thumb, also tacking the two V's back at either end. Stitch from corner to corner only, as from *a* to *b*, keeping as close to the edge as possible. Turn the flap down, press the edges inside through the opening up towards the shoulder, keeping them perfectly level, and baste for stitching [**26**].

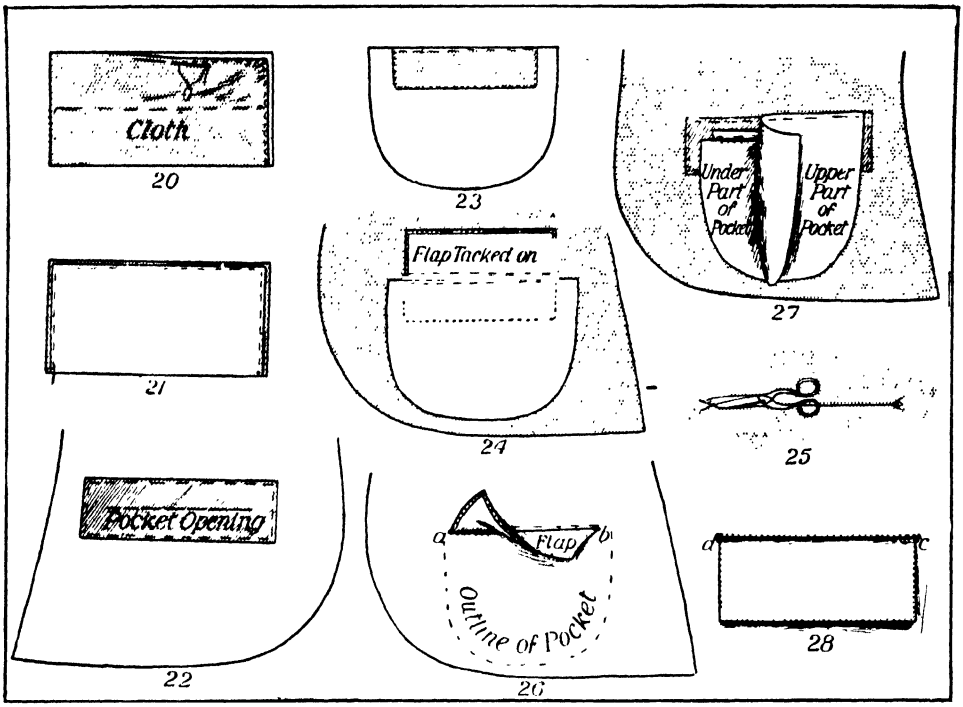
Now take the back of pocket, which must be 1 in. longer than the front to allow of its being stitched in with the flap, turn the fore part of coat wrong side uppermost, and place the Silesia 1 in. above the opening; then baste along the top [**27**].

Turn over on the right side, make the ends neat, pressing the V's back with a needle, stitch along the top of flap as close to the edge as possible, beginning ¼ in. below the flap, and terminating ¼ in. below it at the other side, thus neatening and strengthening the ends. Secure the ends of pocket-mouth with two more rows of stitching, and finish off in the shape of a D, as from *c* to *d* [**28**].

Tack round the pocket, and stitch, beginning ½ in. from opening and stitching through the linen stays at both ends of pocket [**29**, **30**, and **31**].

We are now ready for the canvas, the selvedges of which should be slightly damped and pressed all over with a hot iron—*not ironed.*

Cut the canvas as shown in diagram of right and left fronts [**29** and **30**], the selvedge to the edge of front, and cut edge overlapping pocket 1 in. Place the canvas on the wrong side of fore part of coat, and baste round the edges, keeping



20—28. THE MAKING OF A POCKET

it easy across the chest, over the shoulders, and round the armholes; cut the canvas 1½ in. from the neck and 1½ in. down, and insert a wedge-shaped piece of canvas about ¾ in. wide and 2 in. long [31].

The shoulder near the neck should be stretched.

Slit the canvas two or three times round the armhole, then pare the former away ¼ in. round the front and neck, and, before proceeding any further, roll the corner over the left hand, and tack with five or six long stitches on the right side, which will prevent the canvas from curling outward.

Take a strip of linen cut selvedge-wise, 1 in. wide, which should be pressed with a hot iron, turn in ¼ in.; place the fold a shade beyond the canvas, baste to canvas from the bottom, holding the linen rather tightly for about 3 in. round the corner, as from *a* to *f*, in **30**. Tack the linen on either side to the canvas. It must be remembered that this should be tacked rather tightly at the point at top and round the neck to within 1 in. of shoulder thread-marks.

Press the linen stay, which has just been put on, round the front and also over the pocket. Place the cloth facing on the table with right side uppermost, and neck to the left hand, put the fore part of coat on the top of this, keeping the edge ¼ in. in from that of facing; put one row of basting from bottom to shoulder to hold in position, and baste round the edges, taking care that the facing is eased at the corners from *a* to *f* [**30**]. Stitch the edges ⅛ in. from linen stay. Take out the bastings, open, and press the seam on the narrow side of sleeve-board, cut away the edges to within ⅛ in., turn inside out, work the edges well under, using a bodkin for the corners to make them a nice shape, then baste round the edge on the inside, keeping the seam ⅛ in. in from the edge. This is very important, and there must also be a tacking down the centre and along the raw edge [**29**].

The right front is made in the same way, but, before the facing is put on, an extra stay must be tacked on for the buttons. This should be a strip of canvas 2 in. wide, cut selvedge-wise, and long enough to hold the first and last buttons (in this case 13 in.). Baste to the front ¾ in. from the edge, and ½ in. from the neck—it must be quite loose when basted on to the under part of canvas—then tack all round to the canvas [**31**].

Proceed now as for the left front, then place the two fronts together and see they are exactly the same length; if not, they should be corrected, and any needed alteration made. Mark the spaces for the buttonholes, 4 in. apart, marking the first ½ in. down from the neck, and ⅜ in. in from the edge, in the same way as shown in **15**.

The holes must be worked on the left front, and ¼ in. longer than the diameter of the buttons, to allow these to go through without any pressure [**13, page 1111**]. Place the left front over the right, with the bar of the buttonholes touching the edge of right front, mark through the eyes of the holes with a piece of pipeclay for the buttons, which, however, should be put on last of all.

Linings. We are now ready for the linings. Cut out the fronts, allowing ¼ in. turnings on the front, and the same amount of inlays on the side, as in the fore-parts of the cloth. The back must be cut large enough to allow a pleat, down the centre, of 1 in.—that is, ½ in. under and ½ in. over, to prevent any tightness across the back when finished.

Tack the fore-parts to the back, beginning at the top, placing the parts marked I and I^a together [15]. Keep the thread marks at the bottom even, and baste the seam ¼ in. in from the thread marks. It is advisable at this stage to tack the shoulders together and to try the coat on, and to make any alteration that may be required at the neck and armhole, either by taking in or letting out.

When this has been done satisfactorily the tacking should be removed from the shoulders, which will make it easier for stitching and pressing the seams.

Stitch the side seams, remove the tackings, open, and press; baste the bottom up to the thread marks, and serge [see SERGING, page 1111] to the coat, but the stitches must on no account show through. To avoid this, a No. 7 or 8 tailor's needle and fine silk or cotton must be used, and only a thread of the cloth must be taken up on the needle.

Remove the basting from the bottom, place over a damp cloth (which must be wrung as dry as possible), and press round the bottom and the fronts. It is most important that the cloth should be nearly dry, or the material will become spongy.

Now put a linen stay on the back of each pocket, securing it firmly and tacking to the armhole [29 and 31].

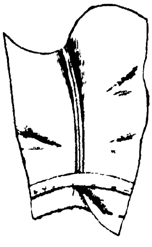
Take the front linings, turn in the front ¼ in., and place ¼ in. over the facing; baste in position, keeping it easy both in length and width, and quite loose round the armhole.

The Back Lining. Place the back lining with the pleat to the centre of back, keeping this also loose in length and width; baste in position, turn in the side seams, tack down, and see that it fits well. Turn up the bottom a little over the edge of the inturn, and baste all round. Tack the shoulders (not the canvas or facing), and stitch; remove the basting, open, and press, stretching the shoulder towards the neck to fit the back.

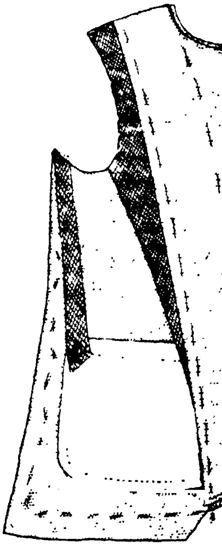
Lay the canvas flat over the shoulders and secure to the turnings; lay the cloth flat over the canvas and secure it to hold in position.

Continue the linen stay from the left fore-part across the back of the neck, to the right; tack the cloth over the linen stay, serge to the shoulders and back, and press. Now fit the lining over the shoulders and tack, but it should not be felled in till after the sleeves are inserted.

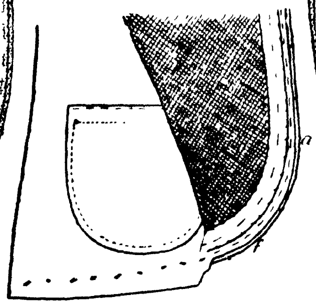
Continued



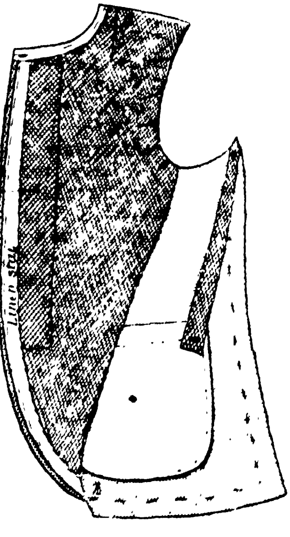
32. THE SLEEVE



29. LEFT FRONT



30. LEFT FRONT, SHOWING CANVAS



31. RIGHT FRONT

Group 5
CHEMISTRY
9

Continued from page 1162

OXYGEN AND OTHER GASES

Commercial Recovery of Oxygen. Oxygen and Life. The Atmosphere. Ozone and the Newly-discovered Gases. The Function of the Sea

By Dr. C. W. SALEEBY

Oxygen and Air. We must now make a systematic study of the most important element. We have mentioned it several times for purposes of illustration. If we were to adhere strictly to our treatment of the elements in groups, we should have to consider oxygen and sulphur together. These two elements have considerable resemblances to one another, and should therefore always be associated in the mind of the student. But oxygen is so supremely important, both as an ingredient of the air and in its relation to life, that it must always dominate our thoughts.

As the reader already knows, it is a gas. It was first discovered by Priestley and Scheele about a century and a quarter ago ; its atomic weight is about 16, and it is thus slightly denser than air, of which it constitutes about one-fifth. It may be prepared in small quantities by Priestley's method of heating the red oxide of mercury, or it may be turned out of water by means of chlorine, or may be obtained from its various compounds by means of electrolysis.

Nowadays, oxygen has attained considerable commercial importance. Since the process of combustion, or combination with oxygen, occurs more rapidly and produces more heat in the presence of pure oxygen than in the presence of air, the element is very frequently used in its pure form in many metallurgical operations It is also largely used in order to produce the brilliant light which is given out by superheated lime and which is called limelight. Its use in this connection has already been explained. Furthermore, pure oxygen is now extensively used in medicine, for there are a large number of diseased conditions in which the inhalation of this gas in its pure form, instead of its ordinary inhalation diluted with nitrogen in the air, is of the utmost value. Hence it has become necessary to acquire some means of obtaining large quantities of oxygen as cheaply as possible.

Brins' Process. The most important of the commercial processes is known as Brins', and is easily explained. The oxide of barium is heated in compressed air to a red heat, and is converted into the peroxide or dioxide, since under these conditions it takes up into itself a certain quantity of the oxygen of the air, the nitrogen of which escapes. Now, when the pressure is reduced, the extra oxygen which has been taken up into the peroxide is liberated again, and can be readily collected. The result of its liberation is to leave behind just the same barium oxide with which the process was started, and so it may go on again and again. Thus, the essential materials for the process are merely air, which has no cost, and barium oxide, which can be used over and over again, and hence the process is exceedingly cheap. The oxygen is stored at a high pressure in a steel cylinder to which a tube can readily be attached, and when a stop-cock is turned, the oxygen rapidly escapes. When the cylinder is being used in the sick-room, the noise made by the escaping oxygen is usually sufficient to indicate that it is escaping, but a simple test can be applied by placing a glowing match-end at the mouth of the tube. If the oxygen is escaping, the rapidity of combustion of the match will be so increased that it will immediately burst into flame.

Oxygen is a colourless, tasteless, odourless gas, forming, as we have seen, eight-ninths of the weight of water, more than one-fifth of the volume of the air, and actually more than one-half the weight of the solid matter that forms the crust of the earth. It is the most widely diffused of all the elements. It has been liquefied and frozen by Sir James Dewar.

Oxygen and Life. By derivation oxygen means the acid-maker, and its function in this respect has already been explained, but it might almost as well be called biogen, to indicate that it is the life-maker. Every living thing, without exception, depends for the processes of its life upon a continuous supply of oxygen. This fact is supremely important and must be carefully studied.

The students of living things tell us that there is a universal function which is common to them all and continuous in them all. This is termed *respiration*. There are no exceptions to this rule, though it was at one time thought that there might be certain exceptions. When the great French chemist Pasteur, the founder of the new science of bacteriology, came to consider the conditions under which bacteria, or microbes, as he called them, grow, he found that they could be divided into two great groups—those that required air for their life, and those that required absence of air for their life. The first he called ærobic, and the second anærobic. At first this looks as if the microbes belonging to the latter group were an exception to our general rule, for it is the presence of free oxygen in the air that arrests their growth ; but it was soon found that unless compounds containing oxygen be present in the materials in which these microbes grow, they immediately die outright. Though they cannot live in air, they cannot, on the other hand, live except in the presence of compounds containing oxygen, which they take from these compounds, thereby, of course, decomposing them. Hence it is true to say that there are no exceptions whatever to the universal rule that oxygen is the life-giving element. There is also the fact that in every kind of living matter, without exception, oxygen is invariably and necessarily found. It is a constant constituent of protoplasm, the "physical basis of life." It is found in proteids and carbohydrates, afterwards to be studied, and though it is not a necessary ingredient of fats, yet it is invariably a constituent of the living part of the curious animal cells in which fat is stored.

Oxidation and Reduction. Now, the process of combining oxygen with any substance is called oxidation, and the process of removing oxygen from any substance that already contains it is known, as we have briefly noted already, as reduction. Changes in these respects occur in a vast majority of all chemical processes, and hence these two words are of the utmost importance and convenience in chemistry. Henceforward we shall use them freely, and assume that the reader is familiar with them. He might expect that the opposite to oxidation would be deoxidation, and that word is sometimes used; but the much more frequent use of the word reduction gives some indication of the importance of this element.

Chemistry of Respiration. Now, let us look a little further into the question of the oxidation of living matter, which is the object of respiration. The products of this oxidation are extremely simple, and consist almost entirely of carbon dioxide (CO_2), and water (H_2O). But biological chemistry has discovered an extremely important fact regarding this process of oxidation. If we consider an ordinary speck of dead oxidisable material exposed to the action of the air, we find, as we might well expect, that it is its outside or its surface which first shows signs of oxidation; the central part of the material can only be oxidised when all the outside is crumbled away in the form of oxide. But the case is profoundly different when we come to consider a particle of living matter similarly exposed to the air. Its respiration by no means consists of a mere oxidation of its surface. What happens is that, in some way which we are yet far from understanding, the oxygen is taken up into the very substance of the living matter and then disposed of. But the reader must not imagine that the means by which human beings breathe is an illustration of this fact; we are referring not to that obvious breathing, but to the real breathing which occurs when the oxygen is brought into contact with the living matter. What we are attempting to describe is true of every living cell, no matter whether it be a cell of one of your muscles to which your blood is now conveying some oxygen just derived from the lungs, or whether it be such another living cell as one of the tiny microbes that exist everywhere. The point is that the living cell, whether it be an independent organism or merely a humble part of a complex organism such as man, is not at all oxidised by the mere action of oxygen upon its surface, but first of all takes up the oxygen into itself, and distributes it in the most complete and intimate way. This is the fact which we attempt to express when we say that the respiration or oxidation of living things is *intra-cellular*—that is to say, *within the cells*. But we may go further; the facts show that before the process of oxidation actually occurs, the oxygen is actually taken up by the very molecules of the living substance, which, indeed, have the most extraordinary power of retaining it when necessary, until there may be need for the production of the energy which results from oxidation. Hence, we must learn the remarkable fact which is described as the *intra-molecular respiration of living protoplasm*. When the living thing dies, the dead protoplasm, if exposed to air, continues to undergo oxidation. But that is of a very different kind. It is now merely the same oxidation, proceeding according to the ordinary physical laws of inorganic nature, that is seen when the surface of any ordinary metal becomes dulled by superficial oxidation.

Oxidation and Growth. We must not be misinterpreted as stating that the laws of physics and chemistry are not applicable in the world of life: we are merely insisting that there is a profound difference, which we are as yet very far from understanding, between the processes of oxidation that may be observed anywhere, and those infinitely more subtle processes of oxidation which are the essential part of the vital function called respiration. The wise reader will compare the facts upon which we have been trying to insist with the statements made in the course on NATURAL HISTORY [page 135]. It is there stated that, unlike the growth of living things, the growth of a crystal "takes place by the addition of layers to the exterior, the interior remaining unaltered." The reader will see that the profound distinction there clearly stated is strictly consistent with the distinction which we have been trying to state here. He will guess that the reason why the living thing, unlike the crystal, can grow from within is the fact that it is able to undergo chemical changes, largely consisting of oxidation, within its very substance, and resulting, not merely in the "growth" of "crystals of sugar-candy on a string," but the true growth which implies development and the accomplishment of a purpose. It is its power of ensuring and directing intra-molecular oxidation that enables the living cell so to distinguish itself.

Ozone. When electric sparks are passed through oxygen—that is to say, ordinary gaseous oxygen—there is formed the allotropic modification of it, which is called ozone, and which has already been described [page 693]. Its formula, we may remember, is O_3; and, in confirmation of this statement, it may be noted that three volumes of oxygen have been proved to form two volumes of ozone, as one would expect, remembering the equation for the conversion of oxygen into ozone already given, and the remarkable law of Avogadro, that equal volumes of gases at an equal temperature and pressure contain equal numbers of molecules. Ozone may not only be produced by the method above stated, but also during electrolysis, and, in small quantities, in the course of very slow oxidation processes, as, for instance, that which occurs when ordinary phosphorus is exposed to the air. At sufficiently low temperatures ozone is transformed into a bluish liquid, closely resembling liquid oxygen. Ozone is, perhaps, the most inconstant of all the ingredients of the atmosphere. This is due to the fact that it is extremely unstable, for reasons that have already been fully explained. A sufficiently keen nose may recognise its peculiar odour, if its possessor goes out, for instance, into a very pure country atmosphere at night, after spending an hour or two in a smoky or badly ventilated room. In the open country, and at the seaside, ozone may readily be detected in the atmosphere ; but wherever there is a quantity of oxidisable organic material in the air—as, for instance, in towns and in their neighbourhoods—ozone is not to be found, since it is decomposed, and ordinary oxygen formed by the reducing action of such organic matter. In all probability ozone cannot be breathed, and is as irrespirable as if it had nothing to do with oxygen. The public generally believes that it is a good thing to breathe air containing ozone ; so it certainly is, but not in the smallest degree for the reason that the ozone is of itself of any value as a gas to breathe, but because its presence in air is *a proof that the air is pure*, the simultaneous presence of organic dirt (gaseous or other) and of ozone in air being impossible, owing to the great activity of this gas as an oxidising agent. Various medical experiments have been made in order to test the utility of ozone, and the statements above made may be regarded as accurately summing up the general conclusions to which those experiments lead. In cases of illness there is often very good reason to increase the percentage of oxygen in the air that the patient breathes, but the intentional addition of ozone to it is unnecessary, and depends on an incorrect explanation of the superiority of sea to town air. As we have observed, the presence of ozone in the former is of value, not in itself, but as an index and proof of purity.

The Atmosphere. By far the most important constituent of the atmosphere, from our point of view, is oxygen, though about four-fifths of it by volume is composed of nitrogen : the percentage of carbon dioxide is ·04. In addition, there is always a certain amount of water vapour, and traces of various compounds containing nitrogen. Until late years the foregoing would have been, more or less, an adequate account of the chemical composition of the air, but it is now known that the air contains a number of other gases which are of very considerable interest. If the air were a compound, the presence of these gases must have been detected long ago ; but since the air is not a compound, but merely a mixture of gases, it is easy to understand how the presence of these recently discovered gases, which occur in only very small quantities, came to be overlooked.

The Discovery of Argon. The initial discovery was made by Lord Rayleigh, who has recently been elected President of the Royal Society. In discussing this very interesting subject we shall follow very carefully the statements and, where possible, the actual words, of Lord Rayleigh himself. He was led to the now universally admitted discovery of the new gas *argon* in the course of some investigations regarding the densities of the most important gases—hydrogen, oxygen, and nitrogen. He found that different results were obtained by different methods of experiment, and it became apparent that the differences were not due to accident or errors of observation, but, as he says himself, " that the complication depended upon some hitherto unknown body, and probability inclined to the existence of a gas in the atmosphere heavier than nitrogen and remaining unacted upon during the removal of the oxygen." This was the means by which Lord Rayleigh, with the aid of Sir William Ramsay, the Professor of Chemistry at University College, London, was enabled to announce to the British Association in 1894 the discovery of a new gas in the atmosphere, though " for more than one hundred years before 1894 it had been supposed that the composition of the atmosphere was thoroughly known." This new gas was named *argon*, which is a Greek word meaning lazy, in order to indicate the fact that it is chemically very inert and has no tendencies to unite with any other substance. This chemical inertness of argon is, of course, one of the reasons why it was so long in being discovered. It is, perhaps, worth noting that certain chemists inclined to the view that argon is a sort of condensed nitrogen having the formula N_3, just as ozone, with the formula O_3, is a sort of condensed oxygen. But that view is entirely disproved. Argon is unquestionably an element, and possesses a very characteristic spectrum [see PHYSICS]. Its atomic weight, according to various investigations, is very nearly 40. So inert is this element that there is still no definite evidence of the preparation of any compound of it whatever, despite a very large number of attempts to produce such combinations.

More New Gases. This discovery, however, like so many others that have been at first questioned, has not only been established, but has led to many more, which stand to the credit of Sir William Ramsay. Argon, so long unknown, actually constitutes nearly one per cent. of the atmosphere. Contrast this with the tiny proportion of carbonic acid. But there have now been isolated from the original argon, so to speak, no less than four other elements, and probably five. The four of which we may be certain are called ***neon*** (Greek for new), ***krypton*** (Greek for hidden), ***xenon*** (Greek for stranger), and, by far the most interesting of all, ***helium***, the name of which is derived from the Greek word for the sun, and was given it for the reason that, as we already noted [page 839], this most remarkable element was discovered in the sun before it was found on the earth. Helium must be discussed at a much greater length when we come to consider a still more remarkable element, *radium*. The percentage of these gases in the air is extremely minute, and, according to Sir William Ramsay, probably the volume of all of them taken together does not exceed $\frac{1}{400}$th part of that of the argon. Now, the remarkable fact which is common to all these five new constituents of the atmosphere is that not one of them can be made to combine with any other substance whatever—in fact, they are all as " lazy " as argon. Each of them has its own characteristic atomic weight and spectrum, but we need not concern ourselves with these. The really interesting thing is the existence of these five elements, which seem, so to speak, to be isolated in Nature ; more especially because we have reason to believe in a *periodic law* which declares that all the elements are related to one another.

The New Gases and the Periodic Law. Now, one of the most important facts which are demonstrated by the periodic law is that the succeeding groups of elements show a regular progression in the number of atoms of other elements with which one of their own atoms is able to combine. This property is called *valency*, and will be considered later. For instance, group one of the elements includes those whose atoms are able each to unite with one atom of any other similar element. Hydrogen and sodium, for instance, belong to this group, and are hence called monovalent—that is to say, their valency is *one*. Oxygen, again, belongs to the second group, and its valency is *two*. The best illustration of what is meant is furnished by the formula of water, which is H_2O, indicating that it needs two " one-handed " hydrogen atoms, so to speak, to unite with one " two-handed " oxygen atom. This is enough to enable us to understand valency so far as we need at present. Now, what is to be done with a group of elements which are incapable of combining at all—elements which have no valency ? Plainly, if the periodic law be correct, they must form a group nothing, or zero, which must fit into the table with all the other elements. Now that is exactly what, indeed, these elements do : directly we discover their atomic weights, we find that they naturally fall into the very places which theory would have predicted for them, and they now form the *zero* group of Professor Mendeleeff's latest table, published in 1904.

For a consideration of a large number of other important facts concerning the atmosphere, the reader must consult the course on Physics. There is little more of importance to be said concerning the chemistry of the atmosphere, though very much that is a matter of life and death might be said if we were discussing the subject of ventilation [see PHYSIOLOGY and HEALTH]. The necessity for ventilation depends upon the fact that the presence of living things in the atmosphere alters its composition to their disadvantage, so that, if they do not move to fresher air, fresher air must be brought to them.

The History of the Atmosphere. If we recall the teaching of geology and astronomy, telling us how the earth was once too hot to sustain life, we shall see that the mixture of gases that covers the solid surface of the earth, and that we familiarly call the air, must have had a very interesting history. According to one widely accepted theory of the earth's origin, all that we now know as the solid earth, and all the liquid matter that now fills the ocean-beds, was once gaseous. The gases of the atmosphere are simply composed of those particular elements which are gaseous at the present temperature of the earth's surface, which have not entered into complete combination with the solid matter of the earth's crust, and which have not been whisked away into space by centrifugal force [see PHYSICS], this being the fate that is supposed to have befallen the former atmosphere of the moon, and some of the lighter constitutents of our own atmosphere. Now, in the past, when the earth's temperature was much higher, and when many other conditions were different, it is more than probable, for instance, that—long before man appeared—the proportion of carbon dioxide (CO_2) in the air was much higher than it is at present. This would account for the extreme luxuriance of vegetation, to which every lump of coal bears witness, the carbonic acid of the air being one of the most important constituents of the food of plants. Again, it is quite certain that, at a very much more remote period, which must certainly date back tens of millions of years, the temperature of the earth's surface was so hot that water could not occur in its liquid form. At that time one of the most important and abundant constituents of the earth's atmosphere was gaseous water, or water vapour.

The Future of the Atmosphere. Whatever the past history of the atmosphere may have been, we can scarcely fail to be interested in the question of its future, upon which the continued existence of the human race certainly depends. It seems at first sight quite evident that there is taking place a very serious, though admittedly very slow, change in the chemical composition of the atmosphere, depending upon the respiration of the countless living things, animal and vegetable, which depend upon it for their life. What is continuously happening day and night in the case of every living thing, without exception, including, for instance, the writer as he forms these words ? His body is undergoing a series of chemical interchanges with the atmosphere, the essential upshot of which is that the air around him becomes poorer in oxygen and richer in carbonic acid. Now this process of respiration and its consequences are common to every living thing, always and everywhere. Hence there appears to be no choice but to believe that the percentage of carbonic acid in the air is slowly increasing, and that of oxygen slowly diminishing. Meanwhile, the students of health remind us that when the percentage of carbonic acid in the air goes anywhere above ·06 such air becomes more or less poisonous to animal life in general, including the life of man. Are we then to believe that the carbonic acid is accumulating, and will continue to accumulate, gradually filling up the valleys and low-lying districts in consequence of its greater weight, and gradually driving human beings higher and higher, until the "last man," gasping for air on some mountain peak, joins his fellows who lie drowned in the sea of carbonic acid beneath him ?

A Compensatory Action. Now, in the first place, we must notice that there is a compensatory action, which is of considerable importance—namely, the action of the green plant, under the influence of sunlight, in decomposing the carbonic acid of the air, retaining the carbon and giving back to the air free oxygen again. This process, however, cannot suffice to dispose of the picture we have suggested, even apart from the fact that its value is largely neutralised, since even the plants that perform this function are also necessarily performing the opposite function of respiration. There is another fact of the very greatest importance, which is of only comparatively recent discovery, and which is of great importance to the theorist, and of incalculable importance in relation to the future of the atmosphere.

A Function of the Sea. In a previous chapter we briefly noted, in reference to the existence of double compounds, that the many salts of sea-water exist in a somewhat peculiar state. If we take a sample of sea-water and proceed to analyse it according to the usual methods, we find that it contains such and such a percentage of sodium chloride, another percentage of salts of magnesium, and so forth. Hence, we might suppose that these salts exist in definite form, and in definite proportion in sea-water ; but it is not so. We know now that the salts of sea-water mainly occur, not at all in definite states, but in states which constantly vary and differ, according to the physical conditions—conditions such as the temperature, the pressure of the atmosphere, the partial pressure of the various gases in the atmosphere, and, indeed, all the other physical conditions that occur. It is the new science of what is often called *physical chemistry* that is teaching us how exactly to correlate such physical conditions with the facts of chemical combination and union.

Now, if the reader remembers our former discussion of the carbonate and bicarbonate of calcium, and the formation of stalactites and stalagmites, he is already completely prepared to understand the most important function of the sea in regard to the composition of the atmosphere. He will remember how an extra proportion, so to speak, of carbonic acid is sometimes added to carbonate of calcium, converting it into the soluble bicarbonate, and how, under certain physical conditions, such as occur when water, charged with bicarbonate, drips through the roof of a cave, the extra carbonic acid is given off to the air, and the insoluble carbonate is precipitated or solidified from out of the water. Now, a parallel series of changes occurs in certain carbonates of sea-water, more especially the carbonate of magnesium. In sea-water there occurs a certain amount of this salt in a more or less stable state, and also a certain quantity of the bicarbonate of magnesium.

But, as we have already seen, there is reason to believe that the proportion which these two salts bear to one another in sea-water depends strictly upon the physical conditions which surround them, the most important of these conditions being the percentage of carbonic acid in the air above the sea [page 1159].

There is thus an automatic, self-regulating mechanism by which the oceans are enabled to preserve the constancy of the proportion of carbonic acid in the air above them, and not only so, but the winds, and that property of gases which we have described as diffusion [see PHYSICS], ensure that the consequences of this process extend also to the air of the land. Of course the discovery of this process is very far from enabling us to reach any positive conclusions as to the more immediate future of the atmosphere. It is evident that the mere absorption (in the form of bicarbonates in sea-water) of the extra carbonic acid which is being constantly added to the atmosphere by the respiration of all living things, and also by every kind of combustion initiated by man for his own purposes, is by no means equivalent to an absolute compensation for this process. All that it accomplishes is to hide the consequences of the process.

Tendency of Chemical Change. There is thus raised the further question, which cannot be considered here, as to the ultimate consequences of the fact that the overwhelming tendency of all the chemical processes that occur on the earth is in *one direction* — a direction which is well indicated by the union of carbon and oxygen to form carbonic acid. The essential consequence of this union is the dissipation of the potential chemical energy [see PHYSICS] of the carbon and of the oxygen in the form of heat energy or kinetic energy, which is scattered and, for practical purposes, lost, though, of course, it is not annihilated. Hence, in considering the future of the atmosphere, we are led on to the study of the remarkable and vastly important theory called by its author, Lord Kelvin, the theory of the *dissipation of energy*.

So much, then, for our chemical discussion of the atmosphere, of which, from our point of view, the oxygen is the essential constituent, the carbonic acid a source of some apprehension, and the large proportion of nitrogen merely a means of diluting the oxygen, which would otherwise be too active for our convenience. We have now to remind ourselves that, when the elements are considered in groups, there is good reason for considering sulphur and oxygen together, and we must therefore pass on to discuss this other important element.

Continued

Continued from page 1196

ORGANS OF RESPIRATION

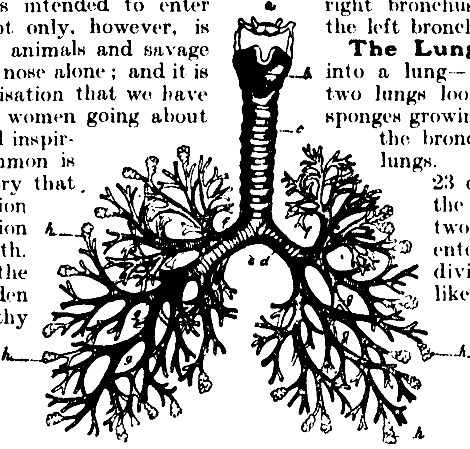
The Nose, Lungs, and Thorax. The Process of Breathing. Inspired and Expired Air. Production of Arterial Blood. Abnormal Breathing

By Dr. A. T. SCHOFIELD

THE respiratory organs include the nose, mouth, larynx, windpipe, lungs, and pleura, with the nerves and blood-vessels belonging to them.

The Nose. We are aware that the nose is not generally included in this category, and the omission has led to serious results. The sense of smell has been considered so exclusively the sole function of the nose that if any child were asked " What is your nose for ? " and it were to answer " To breathe with," the reply would create great astonishment. Yet this is undoubtedly the primary function of the nose, and all inspired air should pass through it. Indeed, it is because it is so designed that the olfactory organ is situated in the upper part to catch the odours the air may carry—a useless position if all the air is intended to enter through the mouth. Not only, however, is this not the case, but all animals and savage men breathe through the nose alone ; and it is only as a product of civilisation that we have the spectacle of men and women going about with the mouth open and inspiring through it. So common is the habit in this country that we found on investigation about half the population inspired through the mouth. Air breathed through the mouth is raw, cold, laden with germs and the filthy dust of streets and rooms, thus drying the tongue, destroying the teeth, causing sore throats and snoring, and clogging and poisoning the lungs.

Air breathed through the nose is warmed, moistened and cleaned so perfectly from all germs and filth, that not one microbe passes down into the lungs.



61. LARYNX, TRACHEA, BRONCHI
a. Hyoid Bone. b. Larynx. c. Trachea. d. Left Bronchus. e. Right Bronchus. f. Larger Bronchial tube. g. Smaller Bronchial tube. h. Cells of Lungs

The nose, therefore, is the first respiratory organ. Its passages are tortuous, and yet free, lined with stiff hairs to intercept foreign bodies, and with ciliated epithelium, that catches all the dust. An abundant blood supply keeps its passages warm, while a free secretion of mucus keeps the air moist. The posterior nostrils are twice the size of the anterior, and through them the air passes behind the soft palate down the larynx. The vocal cords, in a quiescent state, afford a free and silent passage for the air to and fro in breathing ; only when used for vocalisation is the passage of the air obstructed.

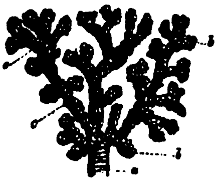
The top of the larynx can be closed tightly by a lid called the epiglottis, but it is never closed save just in the act of swallowing, when it shuts down as the tongue is carried backwards.

The mouth serves for expiration equally well with the nose, the special function of which is inspiration.

Passage of the Air. The air, then, enters by the nostrils (you can see how they act if you watch a horse breathing), and passes backwards through the posterior nares (nostrils) into the throat, and then down through the epiglottis, which is open, into the larynx, or voice box. The air, passing through the larynx, then enters the windpipe, which is called the trachea, because it feels rough outside on account of the 16 to 20 rings of gristle that surround it. This pipe is an inch in diameter, and 4½ in. long. Just behind the breast-bone it divides into the right bronchus (almost horizontal) and the left bronchus (almost vertical) [**61**].

The Lungs. Each *bronchus* runs into a lung—the two bronchi and the two lungs looking just like two huge sponges growing on two stout branches, the bronchi forming stalks to the lungs. The right lung, weighing 23 oz., is in three lobes, and the left, weighing 19 oz., is in two lobes. When the bronchi enter the lungs they rapidly divide and subdivide, exactly like the branches of a tree, until at last the twigs get very small (only one-fortieth of an inch in diameter). Each tiny twig then ends in an air-cell one-fiftieth of an inch in diameter, somewhat the shape of a grape, only the outside is *not smooth*, but like a raspberry or blackberry [**62**]. A bunch of these cells fixed on the little air twigs looks very like a bunch of grapes. When the air gets as far as this, its further progress is stopped. The outer sides of these air-cells are covered with such myriads of blood-capillaries that it is said that if those in the lungs alone were stretched out in one straight line they would reach from here to America. These capillaries differ from those in the body, for those brought food to the cells and took away the refuse ; they gave up all the fresh air from the corpuscles to the body-cells, and took away carbonic acid gas. These bring the bad air and take away the fresh. The red corpuscles that arrive here laden with carbonic acid gas, and of a dark colour, thus have them filled again with oxygen, and changed to a bright red colour. The walls of the capillaries and of the air-cells are so thin that the oxygen from the air can easily pass out of the cells into the blood, and the carbonic acid in the corpuscles can easily pass out of the blood into the air. All animals inspire oxygen and give out carbonic acid gas; and in all there are lungs, or the principle of a lung, which consists essentially of a thin membrane with air on one side, and blood in small thin vessels on the other. The gills of a fish, for instance, are formed on this principle. The water, with air dissolved in it, has free access on one side to a thin membrane on the other side of which the blood circulates.

The blood, thus purified, then returns by the four pulmonary veins to the left auricle of the heart. Both the bronchi, the bronchial tubes, and the windpipe are lined with *ciliated epithelium*, the hairs of which are always waving upwards towards the throat, and so pass up any grains of dust that may be breathed in.



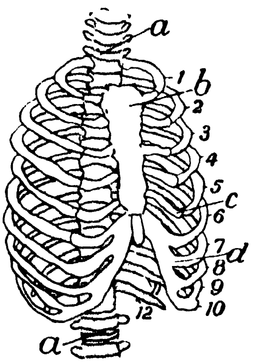
62. TERMINAL AIR CELLS OF LUNG

a. Small air tube. *b*. Terminal air cells. *c*. Smaller air tube

These bunches of air-cells, then, are all matted together by fibrous tissue, blood-vessels, and nerves, into the spongy substance we call lung.

The Pleura and Thorax. Covering each lung with the double folds of an empty bag, after the fashion of the pericardium round the heart, already described, is the pleura, right and left. The outer layer of the bag (the parietal layer) adheres to the inner side of the thorax or chest wall, lining it with a smooth and glistening membrane. The inner layer (the visceral) is equally adherent to the lung, which lies close against the chest wall. Between the two layers is a little fluid that lubricates the two surfaces and enables the one to glide upon the other in the incessant movements of respiration, without friction and without noise, thus performing the work of a universal joint.

So much, then, for the structure of the respiratory organs. The thorax itself [63], which is filled by the heart and lungs, and large vessels, consists of a dome-shaped cavity, closed in at the top by the ribs and fleshy part, the only opening into the lungs being through the windpipe. Its back is formed by the spinal column, its movable sides by the ribs, which are each jointed behind to the backbone, and the upper seven pair in front to the breastbone. The next three are each joined by cartilage to the pair above them, whilst the last two are free in front. The lungs are thus shallow in front (down to the 6th ribs), and deep behind (down to the 11th) The floor of the thorax is formed by a strong muscle (the diaphragm) stretching right across the body, slanting downwards behind, through which the blood-vessels and gullet pass.



63. THE BONES ENCLOSING THE THORAX

a. Vertebral column: 1-12. Ribs. *b*. Sternum. *c*. Costal cartilages. *d*. United cartilages of upper false ribs. 11 and 12. Floating ribs

Mechanism of Respiration. We will now proceed to consider the mechanism, muscular and nervous, of respiration. The force expended in opening the chest in inspiration each day is enough to raise the person the height of St. Paul's, and is thus only about one-sixth of the force spent in the circulation. The surface of blood that is exposed to the air [64] at each breath in the thin film in the capillaries outside the air-cells is equal to about fifty-six square yards.

Breathing consists of two acts—*inspiration* and *expiration*. *Inspiration* is a *forced muscular effort* performed by *three* distinct sets of muscles—those that act on the ribs, those that act between the ribs, and the diaphragm, which is the floor of the thorax.

In inspiration *the chest-cavity* is made broader, longer, and deeper. When at rest, the ribs, hinged behind to the backbone and in front to the breastbone, hang down like the iron handle on the side of a bucket. Now, if you raise such a handle, it not only moves upwards, but outwards. The same takes place with the ribs—and, in addition, the sternum, or breastbone, being movable, rises forwards as well, and thus the chest is made *broader* and *deeper*. It is made *longer* because, when at rest, the diaphragm muscle forms an arched floor, that rises like a dome into the thorax, and on which the lungs rest. As this muscle contracts it flattens the floor, pulls the lungs down, and so makes them longer from top to bottom.

The muscles that raise the ribs are in two sets—those that act on the ribs and those that act between them. The upper ribs are pulled upwards by muscles passing down from the neck.

Between each rib is a double layer of muscles, crossed like an x; they are called the intercostal muscles, because they are between the ribs [65]. The top ribs being fixed as these contract, they tend to raise the lower rib, to which they are attached; and thus, by acting together, all the ribs are elevated.

This constitutes the movement of Inspiration.

In Expiration, *the chest returns to its original size* without effort. This is mainly caused by *elastic recoil*. The lungs are full of elastic tissue, which is stretched when the lungs are expanded; and, as soon as the muscular effort ceases, the elastic force is so great that the lungs pull the ribs down again, and pull up the floor of the diaphragm [66].

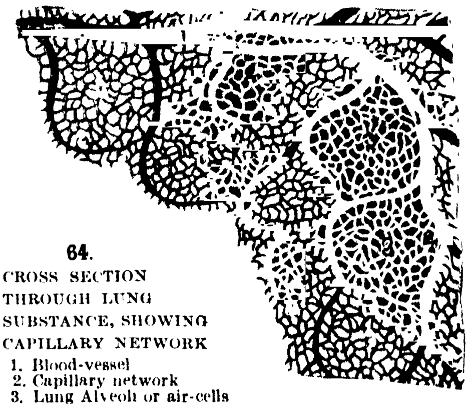
You will notice when you draw in a breath that the abdomen swells out. This is caused by the contraction of the diaphragm, which presses all the digestive organs down and makes them bulge out the walls. In expiration the abdomen gets flat again, as the floor rises once more.

The force required to stretch out the elastic tissue in ordinary inspiration is equal to 170 lb.; and the total daily force used in respiration is 21 foot tons.

The Nervous Mechanism. The nervous mechanism of respiration is of great practical interest. There are two great centres in the brain where respiration is controlled—the one in the Conscious region, under the control of the will, and hence voluntary; the other in the Unconscious region, involuntary, and governed by the unconscious mind.

The Muscular Mechanism. The movement of the muscles is controlled from these centres by various nerves, notably the pneumo-gastric.

Practically our breathing is under our own control up to the point where life is involved. We can breathe in any manner and at any rate we please. Were it not so, speaking would become impossible. We can also hold our breath up to a certain point; but when life is beginning to be threatened the other involuntary centre comes into play, and, in spite of the strongest effort of will, forces us to breathe. This is a merciful and necessary provision to safeguard us against our own folly, and is paralleled by many similar facts in protective physiology. As it is, suicides are far too common; but imagine the loss of life, if every time one were vexed or desperate and wished to die one had only to lie back in a chair or bed and hold one' breath! Why, thousands would die every week. But this is not possible on account of the unconscious control of respiration. This control also acts continuously when we we are not thinking of our breath at all. None of the vital processes require our constant attention; yet with some we are allowed to play up to the point of danger, but no farther.



64.
CROSS SECTION THROUGH LUNG SUBSTANCE, SHOWING CAPILLARY NETWORK
1. Blood-vessel
2. Capillary network
3. Lung Alveoli or air-cells

Respiration of Men and Women. We now come to consider different types of respiration, a matter of great interest.

It has always been observed that the sexes breathe differently, and it has been thought, and laid down in text-books, that the difference is a part of the many distinctions between men and women.

Children of both sexes up to puberty were observed to use all their ribs in expansion, and the diaphragm by descending in inspiration. But from this age the types began to diverge. Girls and women breathed increasingly with ribs only, the diaphragm remaining stationary, and very many women with the upper six pairs of ribs only. Men, on the other hand, tended to breathe less with their ribs, and more by descent of the diaphragm.

It is now discovered that this variation is chiefly due to the difference of dress, and that if a woman be always dressed as a man she breathes in the same way. Diaphragmatic breathing involves a change of two or three inches in the circumference of the waist, and when this is enclosed in a rigid dress-band somewhat smaller than the least waist size (to say nothing of corsets), it is evident that movement of the diaphragm becomes impossible. If the corsets be at all rigid, the lower ribs also become fixed, and the whole strain of respiration is then thrown on the upper half and most delicate part of the lungs, the place indeed where consumption almost invariably begins; while the stationary lower half is a favourite seat of congestion. This is bad enough in quiet life, but in active exercise, such as games and dancing, it becomes positively dangerous.

Man, on the other hand, having never had a rigid waistband, breathes abdominally, and does not move the ribs so much, as all hard work with the arms requires the chest wall to be more or less rigid.

Of course the reason why the waist expands so in abdominal respiration is because the descent of the diaphragm presses down the viscera and bulges out the walls. Hence, in those accustomed to breathe thus, when there is any distension in the abdomen, the breath gets embarrassed because the diaphragm cannot descend.

Changes in Respired Air. We must now consider the air that is respired. We only take our solid and liquid meals three or four times a day; our air-meals, or breath, we have to take 17 times a minute! The air we breathe (if pure) consists of one part of oxygen and four parts of nitrogen, with just the least trace only of carbonic acid gas. The nitrogen is only used to *dilute the oxygen*, as water is used to dilute brandy, for the oxygen would be too fiery without it. Oxygen supports combustion, and enables all substances to burn, but will not burn itself. The heat of the body is kept up entirely by a process of slow combustion. Rapid combustion produces a *flame*, as when gas burns in air; slow combustion produces *smouldering*, as in the end of a match or cigar, or a red-hot poker. But there is a slower combustion that only produces *heat*, as when a little sulphuric acid (oil of vitriol) is poured into a glass of water. There is no flame or burning, but the water gets quite warm. This is the sort of combustion that takes place in the body.

Oxygen not only keeps up the fires of life; it also renews the material. All the body-cells continually need it to repair their tissues, and here also it is slowly used up.

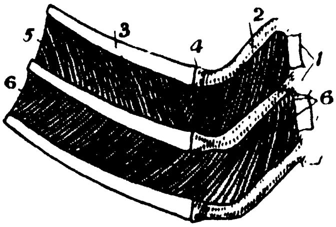
Respiration goes on, however, not only to supply the body with oxygen, but to get rid of the carbonic acid and water that is produced by the combustion and the waste of the cells. The solid part of cell-refuse is called urea, and is carried off in the urine by the kidneys, together with a great deal of the water; but all the gas and part of the water are carried off by the lungs in the process of respiration. The skin does a little respiration also—about $\frac{1}{150}$th part of that done by the lungs.

Good Air. It is of the utmost importance that the air we breathe should be pure. The food we take has often to be brought great distances to get it good and pure, but we are always obliged to breathe the air that is close around us; so we should never live or sleep in close, impure, unventilated rooms. If we do, we cannot be healthy, for we cannot get pure air to breathe.

If we breathe the air in a room where a number of people are crowded together, it is not only full of *poisonous carbonic acid gas* from their breath, but full of *decaying particles of animal matter* given off from the skin and lungs of so many people.

The air we inspire, as a rule, is fairly *dry, cool,* or *cold;* is full of *dust*, and other particles, and is composed of *one part of oxygen and four parts of nitrogen.* The air is drawn into the lungs by their being stretched out and made so much larger by muscular effort that a vacuum is produced, and the air rushes in to fill the space.

The amount of air taken in at an ordinary breath is 20-30 cubic inches. This is called *tidal air*, for it goes in and out like the tide. If you take a very deep breath, you can draw in 100 cubic inches more, which is called *extra*, or *complimental air.* Now, when you have expired this and the tidal air, if you breathe out very hard you can expire another 100 cubic inches of air, called *reserve air*, and then, when the last particle of air has been breathed out, there still remain, far down in the air-cells, 100 cubic inches of fixed or *residual air* that never leaves the lungs.



65. THE INTERCOSTAL MUSCLES

1. Sternum. 2. Cartilages. 3. Ribs. 4. Junction of ribs with cartilages. 5. External intercostal muscles. 6. Internal intercostal muscles (laid bare on the left)

You will easily understand that if the lungs hold ordinarily 230 cubic inches of air, and can be made to hold 330, the 30 we breathe in and out only just moves the air in the larger tubes, and never reaches the air-cells at all.

The wonder, then, is how the fresh oxygen ever gets to the blood if the air-cells and smaller tubes are always filled, as the depths of the ocean are with water, with an air that never moves. This is due to the law of diffusion of gases, by which any two different gases brought together at once change places.

When we draw a breath in, charged with pure oxygen, the fixed air beneath in the cells, full of carbonic acid from the blood, at once gives up this gas in exchange for the oxygen, while the nitrogen never moves at all. Were it not for this law, fresh air would never reach the blood at all. We quite understand that carbonic acid gas is not made in the lungs, but all over the body, and all that takes place in the lungs is its exchange for oxygen.

Expired Air. Expired air differs in every way from inspired air. The analysis of the two is as follows:

Inspired Air:		Expired Air:	
		Ammonia and org. salts	·4
CO_2	·04	CO_2	4·1
N	79·15	N	79·5
O	20·81	O	16
	100·0		100·0

In short, four parts of oxygen are replaced by four of CO_2.

Expired air is *hot*, about blood-heat, *full of water*, contains *no dust*, but much *decaying animal matter*, a considerable amount of *carbonic acid gas, less oxygen, and the same amount of nitrogen.*

You can prove this by experiments:

1. *To show it is hot.* Breathe on the bulb of a thermometer, and you will see it will rise to about blood-heat.

2. *To show it is full of water.* Breathe on a cold looking-glass, or the blade of a steel knife, and you will see it is soon covered with drops of water. When the air is cold, you can actually see the water vapour coming out of your mouth or a horse's nostrils.

3. *To show it contains carbonic gas.* Buy a little lime-water, or make it by mixing quicklime with water, letting it stand, and pouring off the clear fluid, which is lime-water.

If you breathe through a piece of tube into this water it will soon become milky, owing to the forming of chalk, which is carbonate of lime, and is made by the carbonic acid of the breath uniting with the lime in the water.

About half a pint of water and half a pound of solid carbon passes out by expiration each day, as well as a great deal of body heat. These amounts increase during life from 1 to 30, remain stationary from 30 to 50, then slowly decrease. The CO_2 expired varies in proportion to the amount of muscle waste from work done.

With quick breathing, rise of temperature, and in the autumn, the CO_2 is less. In the spring, and under opposite conditions, it is more.

Of 100 parts of CO_2 daily expired, 52 parts are expired in 12 hours during the day, and 48 in 12 hours at night.

Of 100 parts of O inspired, 33 parts are absorbed in 12 hours during the day, and 67 in 12 hours at night. This shows that it is more important that the air breathed at night be pure than the day air, contrary to what is generally supposed. In exercise one-third more air is required.

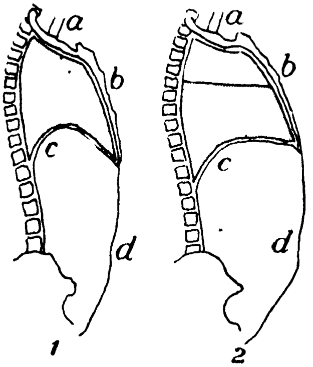
How Arterial Blood is made. We must now describe the changes effected in the blood by respiration.

The venous blood, laden also with organic refuse from the tissues and from the lymphatics, arrives at the lungs through the pulmonary artery from the right heart, and is spread out in the finest capillaries on the outside of all the air-cells. There, not by mere filtration, but by what is believed to be some vital action of the air-cells, a little over 4 per cent. of CO_2 is introduced into the air together with about ·4 of effete animal matter and ammonia out of the blood, while to keep the balance, a corresponding amount of O is introduced with the blood, with the effect of at once making it bright scarlet.

The following experiments will illustrate the way in which the change between the two gases takes place in the lungs:

1. If blood is allowed to run from a vein, and form a clot in a plate or saucer, the outside of it will be seen to become bright red, because the carbonic acid passes into the air, and the oxygen takes its place. But underneath, or inside, it remains quite dark, and if you suddenly turn it over, you see this, though the dark part soon becomes bright when exposed to the air.

2. If you get a little bright blood in a moist bladder and hang it in a jar of carbonic acid gas, it gets purple. If you now hang it in the air in a jar of oxgyen, it gets bright red again, showing that the gases can pass through the walls of the bladder as they pass through the air-cell membrane. Such, then, is the normal process of respiration; but various abnormal processes occur.



66. FORM OF THE STERNUM, DIAPHRAGM, AND ABDOMINAL WALL IN (1) EXPIRATION, (2) INSPIRATION

a. Trachea. b. Sternum. c. Diaphragm. d. Abdominal wall. The dotted portion represents the stationary air

Abnormal Respiration. *Dyspnœa*, or difficulty of breathing, culminating in breathlessness, is due rather to deficient oxygen rather than excess of CO_2, as is shown by experiment. But at times, as in breathlessness caused by excessive exertion, as from running races, it is caused by the CO_2 from the used-up tissues accumulating faster than it can be got rid of.

Apnœa, or ceasing to breathe, occurs at death, and also temporarily after several rapid inspirations.

Asphyxia follows failure in the supply of oxygen. There is first exaggerated breathing, then convulsions, then exhaustion and death. The blood accumulates in the right heart, and becomes venous all over the body.

Excess of CO_2 does not produce asphyxia, but narcotic poisoning.

Ordinary expiration is quite quiet, because the larynx is kept widely open, and the two bands known as the vocal cords are far apart. If they are brought together, however, some sort of sound is made in expiration. Talking and singing, groaning, laughing, coughing, all take place in this way.

Sound is only formed in the larynx, words are made in the mouth. In laughing the breath comes out in a series of explosions; coughing is very similar. The breath seems to burst open the vocal cords. Indeed, the two are so much alike that if a person laughs and coughs at the same time it is hard to tell the one from the other.

Sighing and gaping are two special forms of inspiration we will explain here. If from any cause insufficient oxygen is getting into the blood, as, for instance, when a boy is sitting writing or studying, and breathing very gently for a long time, the nerve-centre that controls the breathing sends an impulse to fill the lungs with fresh air, and he heaves a sigh, which is thus an effort of Nature to get enough oxygen. Panting is an effort made for the same reason.

Yawning is a still more determined effort of Nature to get all possible air into the lungs. The head is thrown back to open the larynx to its fullest extent, the nostrils and mouth are both widely opened, and all the muscles are used; the arms are extended, and the body is thrown back so as to stretch out the lungs to the greatest possible size, and thus supply the blood with plenty of oxygen.

Hiccough, coughing, sneezing, sniffing, sobbing, laughing, sucking, are examples of various forms of inspiration and expiration of special character and for other purposes than ordinary respiration.

Continued

Continued from page 1152

POETRY OF THE NINETEENTH CENTURY

1. A Biographical and Critical Survey of the Poets of Last Century before Tennyson, and the Influences on their Work

By J. A. HAMMERTON

THE poetry of the nineteenth century has its roots in the work of the eighteenth century. Its branches stretch forward into the century that is yet in its infancy. In its style, a notable characteristic is a certain reaction against artificiality and mere rhetoric. In the spirit of it is distinguishable the influence of the Germany of Goethe and Schiller; of the France of Rousseau and Victor Hugo; and of the "problem" writers of Norway and Denmark. The movements toward political freedom in France, Italy, and Greece, and the evolution of English democracy have all affected it vitally. Thus, to its understanding must be brought some knowledge of the historic happenings amid which it arose and flourished.

It is possible to take the works of two or more of the greatest poets of the period, and to derive pleasure from the isolated perusal of them. But while there is much to be said for the study of the poetry of any writer for its own sake, too general a neglect of "books about books" is certainly to be avoided. The more we know of the main facts in the life and times of a great writer, the better shall we understand and appreciate what he has written. It is "the man behind the book" we are interested in, as Carlyle pointed out. So far as the poets and poetry of the nineteenth century are concerned, there is no lack of adequate guidance. The field is a wide one, and its flowers and fruits are varied. In all, something like two hundred names claim consideration. Of these, however, three or four are of outstanding importance; and rather less than thirty need engage those to whom poetry does not make a very strong appeal. Before taking up the study of any one of these writers, the reader could hardly do better than glance at the names in such a series as the "English Men of Letters," and, selecting the monograph dealing with the author he purposes taking up, make this the groundwork or starting-point of the study proper.

The Forerunner of Wordsworth. GEORGE CRABBE (b. 1754; d. 1832) is a particularly interesting figure to readers of the SELF-EDUCATOR. He was, to a very considerable extent, self-taught. In his verse, says Canon Ainger, "pity appears, after a long oblivion, as the true antidote to sentimentalism. The reader is not put off with pretty imaginings, but is led up to the object which the poet would show him, and made to feel its horror." The horror Crabbe chose to describe was that of the sordid side of English village life as he witnessed it in his native Suffolk.

Influenced by Gray, Goldsmith, and Pope, Crabbe is spoken of as the chief founder of the rural school, and as the forerunner of Wordsworth. He applied the lash to the ignoble rich as well as depicted with graphic realism the lot of the ignorant poor. We read Crabbe for what he says more than because of his style, which is unequal and frequently faulty. His knowledge of humanity is extensive; but he lacks both fancy and a sense of humour.

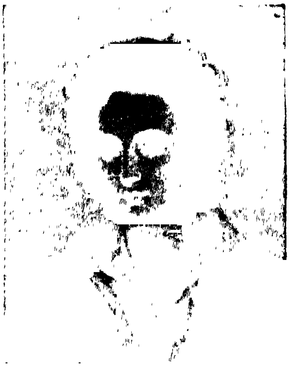
A Group of Lesser Poets. WILLIAM GIFFORD (b. 1756; d. 1826) was a shoemaker's apprentice. A giant, he used his strength like a giant. His two satirical poems, "The Baviad" and "The Mæviad," crushed out of existence the insipid poetry of the so-called "Della Cruscan School"; and to him is generally, but erroneously, attributed the "Quarterly Review's" famous (or infamous) attack on Keats's "Endymion," which was the work of J. W. Croker. He translated "Juvenal" and edited some of the old dramatists. WILLIAM BLAKE (b. 1757; d. 1827) is a link between the Elizabethans and Wordsworth. His love of children speaks to us in his "Songs of Innocence," his feeling of horror at the bitter side of life in his "Songs of Experience." He was a mystic, with something of the contrast of simplicity and subtlety in his work that is characteristic of Browning's poems; and he felt keenly and expressed keenly social wrongs and ecclesiastical tyranny. Like Crabbe, he had to fight poverty, and owed his knowledge to his own efforts towards self-improvement. Like Crabbe, he is again becoming popular; but perhaps his most enduring fame rests upon his skill as an artist. SAMUEL ROGERS (b. 1763; d. 1855), that "grim old *dilettante*, full of sardonic sense," as Carlyle called him, wrote a long poem in heroic metre on "The Pleasures of Memory," and caught, in his blank verse poem, "Italy," some of the beauties of that southern land. He had the wisdom to decline the Laureateship. ROBERT BLOOMFIELD (b. 1766; d. 1823), first a rural "hand" and then a shoemaker, wrote, in a London garret, "The Farmer's Boy," which gives a sympathetic view of the life indicated by its title. He derived his style from Thomson's "Seasons." Another poet of nature and the poor, though on a much higher level, is JAMES HOGG (b. 1770; d. 1835), the "Ettrick Shepherd," who stands next to Burns in the order of Scotland's peasant-poets. He described himself to Scott, to whom he sent contributions for the latter's "Border Minstrelsy," as "King of the Mountain and Fairy School of Poetry," and this piece of self-description is accepted by the critics. "When the Kye Come Hame" and "Kilmeny" (the last-named from "The Queen's Wake," a series of legendary tales and ballads supposed to have been sung by the Royal bards at Holyrood) are among Hogg's most popular, and deservedly popular, compositions. There is more that is enduring in the poetry of Hogg than in that of any of the others we have named since Crabbe, and the general reader, no less than the student, must devote considerable attention to his works, though his prose writings need not engage any but the student.

WILLIAM WORDSWORTH

Wordsworth's Life. WILLIAM WORDSWORTH (b. 1770; d. 1850) is one of the greatest poets of the nineteenth century. Indeed, his influence, which was of slow growth at the outset, is growing yet. He came of an old-established family, and in his early days was greatly influenced by the ideals of French Republicanism and the teaching of William Godwin, the author of "Political Justice," a work basing morals on necessity, who also had a marked influence on Coleridge. When France, having first debased them, forsook her humanistic ideals for dreams of world conquest under Napoleon, the effect on Wordsworth would have been disastrous but for the devotion of his sister Dorothy and the fact that a legacy of £900 left to the brother and a sum of £100 bequeathed to the sister enabled them to settle down quietly, first at Racedown, in Dorset—where Wordsworth's one tragedy, "The Borderers," was written—then to Alfoxden, by the Quantock hills—which district inspired his and Coleridge's contributions to the volume of "Lyrical Ballads"—and, finally, at Grasmere. This was the home of the Wordsworths from 1799 till the poet's death, the three places of residence there being Dove Cottage, Allan Bank, and Rydal Mount respectively. "The Prelude; or, the Growth of a Poet's Mind," an autobiographical poem in blank verse, reflects the influence of Continental travel—Wordsworth visited Germany, Italy, and Switzerland as well as France—and the philosophical views of Godwin. That poem and "The Excursion" are parts of a scheme which was never completed.

JOHN KEATS

LORD BYRON


P. B. SHELLEY

S. T. COLERIDGE

Wordsworth as a Critic. Wordsworth has to be considered in three aspects—as a critic, as a teacher, and as a poet. His critical opinions may be studied in the preface and appendix to the "Lyrical Ballads," the preface to "The Excursion," and in numerous letters. In the preface to the "Lyrical Ballads" he writes as follows: "It may be safely affirmed that there neither is, nor can be, any essential difference between the language of prose and metrical composition. We are fond of tracing the resemblance between poetry and painting, and accordingly we call them sisters; but where shall we find bonds of connection sufficiently strict to typify the affinity betwixt metrical and prose composition? They both speak by and to the same organs; the bodies in which both of them are clothed may be said to be of the same substance, their affections are kindred and almost identical, not necessarily differing even in degree." Pursuing the same idea, he writes in the appendix to the "Lyrical Ballads" that "metre is but adventitious to composition," and that "the phraseology for which that passport is necessary, even where it may be graceful at all, will be little valued by the judicious."

The best proof of the error inherent in the view of poetry thus set forth, which runs counter to all we agreed upon at the outset of this course, is to be found in Wordsworth's own work. Elsewhere, in his intense scorn for the artificial and the meretricious, which were so characteristic of much of the poetry of the eighteenth century, Wordsworth went to the verge of the trivial. But though he raised a storm of criticism, which delayed due recognition of his surpassing genius and is not yet exhausted, it is well to remember with Coleridge, one of the greatest of literary critics, especially where Wordsworth is concerned, that but for the prefaces and appendices much of what has been said against Wordsworth's poems would be reduced to absurdity. The few pages that gave such an opportunity to the pungent parodists of "Rejected Addresses," to Byron, to Leigh Hunt, to Jeffrey, and to others to pour scorn on Wordsworth, would, but for the fear that they represented an intention to overthrow the accepted canons of art, have been "passed over in silence as so much blank paper, or leaves of a bookseller's catalogue," and "only regarded as so many light or inferior coins in a rouleau of gold."

The Teaching of Wordsworth. As a teacher Wordsworth expressed his purpose to be: "To console the afflicted, to add sunshine to daylight by making the happy happier, to teach the young and the gracious of every age to see, to think, and feel, and, therefore, to become more actively and securely virtuous." It will be seen from this he took his vocation seriously. "The poet," he averred, "is a teacher. I wish to be considered as a teacher or as nothing." What did he teach ? George Brimley, in one of the most brilliant of his essays, written in 1851 and still applicable, contends, with reason, that the value of Wordsworth's teaching "lay mainly in the power that was given him of unfolding the glory and the beauty of the material world and in bringing consciously before the minds of men the high moral function that belonged in the human economy to the imagination, and in thereby redeeming the faculties of sense from the comparatively low and servile office of ministering merely to the animal pleasures. . . . He has shown the possibility of combining a state of vivid enjoyment, even of intense passion, with the activity of thought and the repose of contemplation. He has, moreover, done more than any poet of his age to break down and obliterate the conventional barriers that, in our disordered social state, divide rich and poor into two hostile nations ; and he has done this, not by bitter and passionate declamations on the injustice and vices of the rich, and on the wrongs and virtues of the poor, but by fixing his imagination on the elemental feelings, which are the same in all classes, and drawing out the beauty that lies in all that is truly natural in human life."

The Poetry of Wordsworth. Was Wordsworth a poet ? Indubitably ; as Plato and Dante were poets. None but a great poet could have written such lines as these from the poem "Composed a few miles above Tintern Abbey," in 1798 :

"For I have learned
To look on Nature, not as in the hour
Of thoughtless youth ; but hearing oftentimes
The still, sad music of humanity,
Nor harsh, nor grating, though of ample power
To chasten and subdue. And I have felt
A presence that disturbs me with the joy
Of elevated thoughts ; a sense sublime
Of something far more deeply interfused,
Whose dwelling is the light of setting suns,
And the round ocean, and the living air,
And the blue sky, and in the mind of man :
A motion and a spirit, that impels
All thinking things, all objects of all thought,
And rolls through all things."

Let the student who seeks to find Wordsworth at his best also ponder the exquisite ode entitled "Intimations of Immortality from Recollections of Early Childhood." But Wordsworth's claim to rank among the immortals might be based on his sonnets alone. From whatever standpoint it may be looked at, the sonnet "Composed upon Westminster Bridge, September 3rd, 1802," is one of the finest in the language :

"Earth has not anything to show more fair.
Dull would he be of soul who could pass by
A sight so touching in its majesty.
This city now doth, like a garment, wear
The beauty of the morning ; silent, bare,
Ships, towers, domes, theatres, and temples lie
Open unto the fields, and to the sky,
All bright and glittering in the smokeless air.

Never did sun more beautifully steep
In its first splendour, valley, rock, or hill ;
Ne'er saw I, never felt, a calm so deep !
The river glideth at his own sweet will.
Dear God ! the very houses seem asleep ;
And all that mighty heart is lying still ! "

There is nothing in the Elizabethan writers of the sonnet to surpass the above in perfection of form. Tennyson never wrote more truly nor with finer insight than when, in Wordsworthian phrase, he declared that the Laureate's wreath came to him.

"Greener from the brows
Of him who uttered nothing base."

It is unnecessary to urge Wordsworth upon the general reader, for he is so securely a popular classic that his poetry is in no danger of neglect.

Coleridge. Chief of Wordsworth's contemporaries was SAMUEL TAYLOR COLERIDGE (b. 1772 ; d. 1834). Coleridge was a talker, a preacher, a philosopher and a mystic. His best work belongs to his early years, when he was inspired by his love of nature and by the revolutionary idealism of France, and when, with Southey and Robert Lovell, he planned the foundation of a Utopia "in the rich heart of the West." Unhappily, all through his life, plans came more easily to him than performance. His life story is one of the saddest in English literary history. His health was poor, and his habits were worse. It is a notable fact that his ballad epic of "Christabel," though a fragment, exercised in MS. form, some twenty years before it was published, a wonderful influence on Scott and other contemporary English poets. "In this weirdly beautiful creation," says one critic, "the spiritual and material are so exquisitely blended that it is difficult to know where they run into each other." For an explanation of the dreamland beauty of "Christabel" and the "Rime of the Ancient Mariner" recourse must be had to the German philosophers, particularly to Goethe, Herder, Schelling, and others of their school, to whom Coleridge was much indebted. Mr. Swinburne says of "The Ancient Mariner" that it is "perhaps the most wonderful of all poems. In reading it we seem rapt into that paradise revealed by Swedenborg, where music and colour and perfume were one, where you could hear the hues and see the harmonies of heaven. For absolute melody and splendour it were hardly rash to call it the first poem in the language." Even so, Coleridge may prove a difficult poet for all save the advanced student and the genuine lover of poetry.

Scott and Tannahill. Sir WALTER SCOTT (b. 1771 ; d. 1832), on the other hand, is essentially a poet for the young. Repelled by the Revolution from visions of the future, he sought and restored to letters the romance of the past. "The Lay of the Last Minstrel," "Marmion" and "The Lady of the Lake," his best poems, are for the million what "Christabel" and "The Ancient Mariner" are for the comparatively few. For pure joy in nature and love of humanity Scott was not excelled by either Wordsworth or Coleridge, though there is a certain mechanical touch in his verse and a mannerism which prevent its being classed with the greatest English poetry.

Another Scots poet, and one of the greatest of song writers, was ROBERT TANNAHILL (b. 1774 ; d. 1810), a Paisley weaver, whose life was sad and ended tragically. His "Braes o' Gleniffer" and "Jessie, the Flower o' Dunblane" are favourite lyrics with Scotsmen the world over, and are assured of immortality.

Southey and Landor. ROBERT SOUTHEY (b. 1774 ; d. 1843), as a poet, is little honoured to-day, though Mr. Saintsbury boldly champions his cause. His change from a democratic to a Tory standpoint (exemplified in the difference between "Wat Tyler" and "The Vision of Judgment") may have had some influence on popular taste ; but his choice of subjects is perhaps the chief reason of the neglect into which he has fallen. Of his longer works, "Roderick, the Last of the Goths" is the best. The others are "Thalaba, the Destroyer," a rhymed epic of Arabia ; "Madoc," a semi-historical poem, descriptive of the adventures of a Welsh prince ; and "The Curse of Kehama," a poem in irregular rhymes, the theme of which is drawn from Hindu mythology. Southey is better known by such spirited ballads as "The Battle of Blenheim," "The Well of St. Keyne," and "The Inchcape Rock." The name of WALTER SAVAGE LANDOR (b. 1775 ; d. 1864) recalls one of the most touching stories in the romance of reality. It is told with exquisite sympathy by Sir William Hunter in the introductory chapter of his "Thackerays in India." Midway in the impetuous rush of his stormy youth Landor found kindness in the family of Lord Aylmer, with whose gifted daughter Rose he fell in love. The affection was mutual. It was Rose Aylmer who lent him the book which inspired the work—"Gebir"—in which his genius first flashed out into enduring flame. Hope told a flattering tale, and then Rose Aylmer was sent out to relatives in Calcutta, there to find an early grave. For days and nights her image never left Landor's brain. "During hours of sleeplessness he wrote the elegy which enshrines in a casket of pearl the name of Rose Aylmer as long as maiden hearts shall ache and the English language endure" :

> "Ah, what avails the sceptred race ?
> Ah, what the form divine ?
> What every virtue, every grace ?
> Rose Aylmer, all were thine.
> Rose Aylmer, whom these wakeful eyes
> May weep but never see,
> A night of memories and of sighs
> I consecrate to thee."

Landor gave a marked impetus to the Romantic movement, and while he is more for the student than for the general reader, the latter must make some acquaintance with his poetry and his prose. The poems of CHARLES LAMB (b. 1775 ; d. 1834) are chiefly valuable as expressions of his gentle nature.

Campbell and Moore. THOMAS CAMPBELL (b. 1777 ; d. 1844) is, like Southey, best remembered by his lyrical poems—"Hohenlinden," "Ye Mariners of England," "The Soldier's Dream," "Lord Ullin's Daughter" and the "Song of the Evening Star," are among them. His "Pleasures of Hope" is an echo of Thomson and Gray. THOMAS MOORE (b. 1779 ; d. 1852), who wrote "Lalla Rookh" and many songs to old Irish airs, had in abundance the double gift of vocal and poetic melody. His poetry, said Jeffrey, was as the thornless rose ; "its touch of velvet, its hue vermilion, and its graceful form cast in beauty's mould." "To me," said Byron, "some of Moore's last Erin sparks—'As a Beam o'er the Face of the Waters,' 'When he who Adores thee,' 'Oh, Blame not the Bard,' 'Oh, Breathe not his Name,' are worth all the epics that ever were composed." But Moore possesses claims in addition to those dependent on the charm of his "Irish Melodies." His latest critic, Mr. Stephen Gwynn, remarking on the increasing virtuosity shown during the nineteenth century in the management of lyric metres, says : "From Cowper and Crabbe to Mr. Swinburne is a strange distance ; and it has not been sufficiently realised that Moore is very largely responsible for the advance. Many critics have noted the change from the strictly syllabic scansion of Pope's school to metres like those of Tennyson's 'Maud,' and a hundred later poems, in which syllabic measurement is wholly discarded. It has been noted also that, even in the freer metres of the sixteenth and seventeenth centuries, lyric writers confined themselves to variations of the trochee or iambic, and that an anapæstic or dactylic measure is hardly found before Waller. But it has been hardly recognised that till Moore began to use these triple feet no poet used them with dexterity and confidence. . . . It is Moore's great distinction that he brought into English verse something of the variety and multiplicity of musical rhythms." Five other poets call for brief mention here :

Other Contemporaries of Wordsworth. EBENEZER ELLIOTT (b. 1781 ; d. 1849), whose "Corn Law Rhymes" have served to distract attention from his transcripts from Nature ; WILLIAM TENNANT (b. 1784 ; d 1848), whose poem of "Anster [Anstruther] Fair" was modelled on an Italian style, which Byron adopted for "Beppo" and "Don Juan," and thus definitely acclimatised ; LEIGH HUNT (b. 1784 ; d. 1859), whose reputation, largely due to his prose writings, would not be inconsiderable were it based only on "The Story of Rimini," and his other and shorter poems, of which "Abou Ben Adhem," and "Jenny Kissed Me" are most familiar ; THOMAS LOVE PEACOCK (b. 1785 ; d. 1866), who wrote a number of delightful lyrics which are to be found in his novels ; and BRYAN WALLER PROCTER ("Barry Cornwall") (b. 1787 ; d 1874), who, while he is better known for his appreciations of poetry than as a poet himself, wrote at least one good song, "The Sea."

Byron. LORD BYRON (b. 1788 ; d. 1824) was some little time ago strongly commended to working-class readers by no less an authority than Mr. John Morley. Since the reaction following the somewhat flattering hero-worship to which he was once subjected, Byron has enjoyed a far greater popularity on the Continent than in England. It is especially true of Byron that without some knowledge of the successive stages of his short but crowded life, his belongings, his surroundings, his friendships, and his fortunes, a great deal of his poetry, as his latest editor, Mr. Ernest Hartley Coleridge, points out, lacks significance. His output was large. It comprises two epics, or quasi-epics, "Childe Harold" and "Don Juan" —which constitute his best work—twelve narrative poems, eight dramas, seven or eight satires, and a multitude of occasional poems, lyrics, epigrams, and jeux d'esprit. As to the dramas, Mr. Coleridge, who reminds us that "Werner" was the only one that took any hold on the stage, considers "Sardanapalus" "by far the greatest and most original" of the "regular" plays. The importance of Byron is well expressed by the same critic : "He brings the wisdom of the many to bear upon his individual experience, 'touching it with emotion,' and re-making it by the potency of his wit. His wisdom is not that of the market, nor of the cloister, nor of the academy, but of a man of the world who has realised and faced the problems of existence. If he 'taught' us little of the spiritual amenities of the soul, he has taught us the limitations of our hopes and fears, and to bear with reverence and submission the burden and the mystery of our fate. He is neither pessimist nor optimist, but he reasons concerning things as they are, and the judgment which is come already." He shows, in short, how hollow are many of the baubles for which a section of democracy craves. He is a keen satirist and a humorist "of the following of Rabelais and Sterne." Coleridge has described him as "the parent of modern fun." According to Dr. Brandes, "French Romanticism and German Liberalism are both direct descendants of Byron's Naturalism." The vogue of Byron's verse-romances induced Scott to turn to prose. "With Byron," says Mr. Gosse, "the last rags of the artificiality which had bound European expression for a century and a half were torn off and flung to the winds. He taught roughly, melodramatically, inconsistently, but he taught a lesson of force and vitality. He was full of technical faults, drynesses, flatnesses ; he lacked the power to finish ; he offended by a hundred careless impertinences ; but his whole being was an altar on which the flame of personal genius flared like a conflagration." In a word, Byron had the true poetic "glamour" ; a personality not to be shackled by any laws of rhythm or rhyme. No reader with any taste for poetry, responsive to the passionate expression of a soul unrestful, will need to be urged to the reading of Byron : once taken up, his poetry has a compelling force unsurpassed, if not unrivalled, by that of any other writer of the century.

Shelley. In the case of PERCY BYSSHE SHELLEY (b. 1792 ; d. 1822), the student of poetry must be warned against being misled by warped and narrow views concerning Shelley's life. Shelley was, as Byron was, a herald of revolt ; but he was also, what Byron could hardly be said to be, an idealist. Byron was at times sincere ; Shelley always so. If Shelley erred, as we may think, against the social conventions, it was not out of contempt nor in any spirit of reckless libertinism, but because he had constructed for himself a philosophy and adhered to it. His principal works are "Queen Mab," "Alastor," "The Revolt of Islam," "Prometheus Unbound," "The Cenci," "Julian and Maddalo," the "Witch of Atlas," "Epipsychidion," "Adonaïs," and "Hellas." In "Queen Mab" were expressed the mingled idealism and atheism of the Revolution. "Prometheus Unbound" is well described as "the finest example we have of the working out in poetry of the idea of a regenerated universe." "Adonaïs" was a lament for the death of John Keats. "The Cenci" is the most powerful drama in English since Otway's "Venice Preserved." Shelley's was a divided personality ; he lived in the world, but all his thoughts soared into the empyrean. As a poet of the imagination, he was immeasurably superior to Byron. Of his lyrics, the "Ode to the West Wind" is as imperishable as anything in English poetry. "At his best," says Mr. Gosse, "Shelley seems like Æschylus, and, at his worst, merely like Akenside."

Keats. To turn from Byron and Shelley to John Keats (b. 1795; d. 1821) is like passing from a storm in which body and soul have been engaged to some sweet resting-place. Keats leaves the problems of passion—whether physical or purely intellectual—alone, and tunes his lyre to hymns of beauty and the praise of nature. He is one of the first of modern literary poets, drawing his inspiration largely from Ancient Greece and Elizabethan England, though the influence of his friendship for Leigh Hunt is distinguishable in his early poems. "Keats," writes Mr. Gosse, "has been the master-spirit in the evolution of Victorian poetry. Both Tennyson and Browning, having in childhood been enchained by Byron, and then in adolescence by Shelley, reached manhood only to transfer their allegiance to Keats, whose influence on English poetry since 1830 has been not less universal than that of Byron on the literature of the Continent. . . . In spite of what he owes to the Italians . . . no poet, save Shakespeare himself, is more English than Keats; none presents to us, in the harmony of his verse, his personal character, his letters, and his general tradition, a figure more completely attractive nor better calculated to fire the dreams of a generous successor." When the critics attacked "Endymion," the attack was meant to reach, through that poem, the detested politics of Leigh Hunt. Not only Browning and Tennyson, but Dante Gabriel Rossetti, William Morris, and Algernon Charles Swinburne owe much to Keats. "Hyperion" is a beautiful fragment; the odes "On a Grecian Urn" and "To a Nightingale," the sonnet, "On first Looking into Chapman's Homer," and the poems, "The Eve of St. Agnes" and "La Belle Dame Sans Merci," stand by themselves in the foremost ranks of their kind. They are the work, be it remembered, of one whose father worked in a livery stable, and who began life as a surgeon's apprentice.

Other Poets of the Early Nineteenth Century. There are many names to be mentioned before we come to the next one of outstanding importance. Among them are Edwin Atherstone (b. 1788; d. 1872), author of "The Last Days of Herculaneum"; Sir Aubrey De Vere (b. 1788; d. 1846), who went to school with Byron, was a friend of Wordsworth's, and wrote several fine sonnets and two dramas of much poetic strength, "Julian the Apostate" and "Mary Tudor"; John Clare (b. 1793; d. 1864), who was the son of a poor labourer, and whose "Poems Descriptive of Rural Life" owed much, as Bloomfield's did, to the influence of Thomson's "Seasons"; Hartley Coleridge (b. 1796; d. 1849), eldest son of Samuel Taylor Coleridge, and a sonneteer of much felicity and gracefulness; George Darley (b. 1795; d. 1846), critic, and author of a pastoral, "Sylvia," and a poem, "Nepenthe," in which, amidst much gorgeous imagery, he worked forward to the apotheosis of Contentment; William Motherwell (b. 1797; d. 1835), a Scots song-writer, whose "Jeanie Morrison" and "My Head is like to Rend, Willie," are classic north of the Tweed; Thomas Hood (b. 1799; d. 1845), whose "I remember, I remember," "The Dream of Eugene Aram," "The Song of the Shirt," and "The Bridge of Sighs," are as truly poetry of the heart as his inimitable humour was original; William Thom (b. 1798; d. 1848), a Scots hand-loom weaver, and author of a remarkable poem entitled "The Mitherless Bairn"; Lord Macaulay (b. 1800; d. 1859), whose "Lays of Ancient Rome" call for mention here; Sir Henry Taylor (b. 1800; d. 1886), whose "Philip van Artevelde" is to be commended as a study in human history as well as an experiment in romantic (literary) drama; Charles J. Wells (b. 1799; d. 1879), the friend of Keats, and the beauties of whose "Joseph and His Brethren," a Biblical drama, were neglected till attention was drawn to them by Mr. Swinburne; William Barnes (b. 1801; d. 1886), the pastoral poet of Dorsetshire; Winthrop Mackworth Praed (b. 1802; d. 1839), a writer of bright, witty "society verse"; James Clarence Mangan (b. 1803; d. 1849), whose life was a tragedy; Richard Henry Horne (b. 1803; d. 1884), whose fine epic, "Orion," was sold first at one farthing per copy, "as a sarcasm upon the low estimation into which epic poetry had fallen"; Thomas Lovell Beddoes (b. 1803; d. 1849), an introspective poet, whose "Death's Jest Book; or, the Fool's Tragedy," proclaims him a good poet if a poor dramatist; Laman Blanchard (b. 1804; d. 1845), who claims kinship with Hood and Praed; Charles Whitehead (b. 1804; d. 1862), author of "The Solitary," and "The Cavalier" (a blank verse drama), who lies, like Chatterton, in a pauper's grave; Robert Stephen Hawker (b. 1803; d. 1875), the inspired poet-priest of Morwenstow; Thomas Wade (b. 1805; d. 1875), who sat at the feet of Shelley, and wrote several excellent sonnets and a number of ambitious plays; Edward Lord Lytton (b. 1803, d. 1873), a genius of protean industry, whose only failure (with the exception of his domestic life) was as a poet; Elizabeth Barrett (Browning) (b. 1806; d. 1861), whose "Cry of the Children," "Casa Guidi Windows," "Poems Before Congress," "Aurora Leigh," and "Sonnets from the Portuguese," bespeak the exquisite tenderness of a womanly woman more than they display the technical excellence of a poet; John Sterling (b. 1806; d. 1844), whose life—it is enshrined in Carlyle's splendid memoir—is his best poem; and Richard Chenevix Trench (b. 1807; d. 1886), a writer of some sincere and simple poetry, a noteworthy divine, and a distinguished philologist.

Every poet named in this group is of some importance to the student, but with the exceptions of Hood, Macaulay, Praed and Elizabeth Barrett Browning, the general reader need not be expected to have more than a partial knowledge of their writings.

Continued

Group 23
NATURAL HISTORY
9
Continued from page 1119

HORSETAILS, MOSSES, & LIVER-WORTS

Structure and Life History of the Horsetail, Club-moss, and Selaginella. Alternation of Generation in Seed Plants Moss Colonies

By Professor J. R. AINSWORTH DAVIS

HORSETAILS (*Equisetinæ*)

The extinct members of the Horsetail group played an important part in the formation of coal vegetation, but all existing forms belong to a single genus (*Equisetum*), most species of which are of comparatively small size. One tropical horsetail (*E. giganteum*), however, reaches the height of over 30 feet, and one of our native forms (*E. maximum*) may be as much as 6 ft. in length.

(*E. arvense*). The small field horsetail of Britain abounds in waste places of damp character, and grows from a creeping underground stem, which it is very difficult to eradicate. Barren and fertile shoots push up from this in spring to the height of about a foot. The former consist of a hollow, jointed stem, from the nodes of which stiff circlets of narrow green branches grow out, the leaves being represented by a toothed sheath at the base of each circlet. These parts are strengthened by a good deal of flinty matter, so much so that this species and its cousin, the Dutch rush (*E. hyemale*), are used for polishing metal.

A fertile shoot possesses leaves but no branches, and ends in a club-shaped "flower" [**182**, where note also one of the toothed leaf-sheaths]. This is made up of a large number of stalked spore-leaves, each of which bears a set of elongated spore-cases, in which numerous rounded spores are produced [**196**], all of the same size, as in ordinary ferns. In some horsetails both fertile and barren shoots bear branches.

How the Spores are Scattered. The covering of the ripe spore splits into four threads, *elaters*, which spread out when dry, but coil round the spore when damp [**196**]. In the former condition they help to push the spores out of their cases, and give an increased surface which helps dispersal by the wind.

Life History of the Horsetail. Although the horsetail spores are all of the same size, they give rise to two kinds of prothallus, male and female, which respectively produce sperm and egg organs. The prothalli are not unlike those of an ordinary fern, and the egg-cells are fertilised in the same fashion.

CLUB MOSSES (*Lycopodinæ*)

The little club-mosses of our moors and mountains are the dwarfed representatives of a group that was dominant in the days when our coal was being formed, at which time many of them were large forest trees. The most striking British species is the stag's-horn club-moss (*Lycopodium clavatum*) [**197**] the long forking stems of which are thickly covered with scale-shaped leaves, and creep along the ground, into which they send roots at intervals. Some of the branches end in elongated cones, comparable to those of horsetails and to the flowers of seed-plants. Upon the bases of the crowded leaves which these bear the spore-cases will be found [**198**], each of them containing numerous yellow dust-like spores, all of the same kind. These minute bodies are very resinous, and therefore extremely inflammable. The yellow

podium" is made up
some of this through a gas-jet a bright flash of light can be produced, which has often done duty for lightning on the stage; and it is interesting to know that some layers of coal are almost entirely made up of the spore-cases of extinct members of the group.

Life History of the Club-moss. The spores of the stag's-horn club-moss germinate to produce small tuberous prothalli, which live underground and form a sort of joint-stock company with a kind of fungus, as we have elsewhere seen to be the case with the roots of certain seed plants. A prothallus bears both sperm and egg organs, and the details of the life history resemble those of ordinary ferns.

Selaginella. Selaginella is a relative of the club-mosses, and is represented by a large number of species which are particularly common in tropical regions. It lives in wet places, and we have one native species (*S. selaginoides*) [**199**], while others (*e.g.*, *S. Kraussiana*) are cultivated in our greenhouses. The plant creeps along the ground after the fashion of a club-moss, but its leaves are thinner and more delicate, in association with the moisture-loving habit. Like a club-moss, too, some of its branches end in cone-like flowers, but the spore-cases are of two kinds [**200** and **201**], producing large and small spores respectively.

Life History of Selaginella. There is here a general agreement with the water-ferns. The macrospore germinates into a small female prothallus [**203**], which projects from the spore and possesses a small number of egg-organs, while the germinating small spore becomes a very minute male prothallus [**202**], which is practically nothing more than a sperm-organ, producing motile sperms, as in many of the cases already described.

We may represent the life history as follows, the same diagram serving for the water-ferns:

$$\begin{array}{lll}
\text{SPORE-GENERATION} & \text{EGG-GENERATION} & \\
\text{Selaginella plant} \left\{ \begin{array}{l} \text{Large spore—female prothallus—egg-organ—egg-cell} \\ \text{Small spore—male prothallus—sperm-organ—sperm} \end{array} \right. & & \left. \begin{array}{l} \text{Fertilised} \\ \text{egg-cell} \end{array} \right.
\end{array}$$

STRUGGLE FOR A FOOTHOLD

There is no doubt that water is the original home of life, and it is only by a long process of evolution that certain groups of animals and plants have become fitted for existence on land. Limiting ourselves, for the present, to the latter, we may say that marshes, swamps, and damp places in general constitute a sort of half-way house between water and land, and play a very leading part in the tactics of forms which are endeavouring to abandon the old aquatic home. It is also important to remember that the life history of any particular organism broadly recapitulates in summary form the evolutionary history of the group to which it belongs. Bearing this in mind, we shall be able to understand the mysterious phenomenon of alternation of generations, of which several cases have been described.

If we take, for instance, the life history of a fern, we find a small, relatively insignificant, egg-generation (the prothallus) living in very moist surroundings, of which the fertilised egg-cells become the relatively large and complex "fern plants" that constitute the spore-generation, and produce spores that germinate into prothalli. The spore-generation, it is true, flourishes best in damp, shady places, but it is far less dependent upon moisture than the prothallus is, and is adapted in many ways to comparatively dry conditions. Its stem and leaves have firm coverings, by which undue evaporation is prevented, and are traversed by strands which conduct liquid from the roots.

We are probably justified in looking upon the insignificant egg-generation (the prothallus) as being the much diminished representative of the remote aquatic ancestors from which the fern has descended, while the "fern plant," the spore-generation, is a special development that has gradually arisen as an adaptation to the conquest of the land. As we pass up the scale to seed plants, we shall find that the egg-generation becomes more and more reduced, and the spore generation of increasing importance. And we shall discover the beginnings of flowers, which are simply special shoots bearing spore-leaves, and giving themselves up to the production of spores, either all of one size, as in horsetails and club-mosses, or large and small, as in water-ferns and selaginella.

Alternation of Generations in Seed Plants. All the fern-like plants are more or less thwarted in their attempts to dominate the land, because they still retain in their life history an egg-generation (prothallus) which is very dependent upon moisture, and partly because the motile sperms, essential for the fertilisation of the egg-cells, have to swim to their destination. But seed plants, though they still retain an egg-generation, have reduced it to very small dimensions, and have so arranged matters that they are no longer obliged, for its sake, to live with "one leg in the water."

Let us, then, briefly consider the life history of a flowering plant in the light of what has just been said. The "plant" itself is the spore-generation, and its flowers are arrangements for producing spores, in this case of two kinds, large and small. The carpels are spore-leaves giving rise to large spores (embryo-sacs), contained in spore-cases (ovules). The stamens are also spore-leaves which produce small spores (pollen grains), developed in spore-cases (pollen-sacs), of which four are embedded in each anther, at least, in pod plants.

The egg-generation consists of male and female prothalli. The male prothallus is very minute indeed, and represented by the contents of the germinating pollen grain. The stigma provides the necessary moisture for germination, or, in naked-seeded plants, this is provided by the scales of the female cones. We may regard the pollen tube as a sperm-organ, and in most cases the motile sperms have been superseded, some of the contents of the pollen-tube passing directly into the egg-cell. But cycads still produce sperms, which swim about in a small quantity of fluid provided for them by the ovule. It is not surprising that these should be present in the cycads, for they are the lowest of the seed plants, and therefore most like the ferns, etc. The female prothallus is represented by the contents of the embryo-sac, and is safely sheltered within the ovule. In a naked-seeded plant, such as the Scotch pine, this prothallus consists of a small mass of cells (endosperm) formed before fertilisation, and of a couple of egg-organs, something like those of a fern, but much reduced, and each producing an egg-cell. In a pod plant the female prothallus is still more reduced, and so are the egg-organs, but there is a large egg-cell. All this may be expressed in the following scheme, which should be compared with that already given for selaginella:

SPORE-GENERATION		EGG-GENERATION			
Seed-plant	Large spore — (embryo-sac)	female prothallus — (contents of e. sac)	egg-organ -- (reduced)	egg-cell	Fertilised egg-cell
	Small spore — (pollen-grain)	male prothallus — (contents of p. grain)	sperm-organ -- (pollen-tube)	sperm (or part of contents of p. tube)	

The conspicuous parts of a flower have been developed, as we have seen, for the attraction of insects or other animals which carry about the small spores (pollen-grains). We have considered the use and nature of seeds, and it will be sufficient to add here that recent research has revealed the existence of extinct plants which possessed what may be called incipient seeds, and which form a link between fernlike species and cycads, the lowest seed plants.

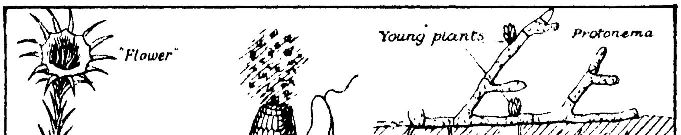
MOSSES AND LIVER-WORTS

(*Bryophytes*)

Descending a step lower in the scale we now come to forms of plant life which are more dependent upon moisture than ferns and their allies. They also have begun the conquest of the land, but have not accomplished so much in that direction. Properly developed roots and strands of tissue (vascular bundles) which convey crude and elaborated sap, and give support, are eminently characteristic of the higher land-plants, or, to speak more correctly, of the spore-generation of such plants. Mosses and liver-worts possess no proper roots, but only root-hairs, and their comparatively small spore-generation is only beginning to develop vascular bundles.

Parts of a Moss-plant [183]. If we examine a fruiting moss we shall see that it consists of a slender stem bearing numerous delicate flattened leaves and brown threads (the root-hairs). Attached to such a plant will be found one or more stalked spore-capsules. There is a well-marked alternation of generations, for the moss-plant itself is the egg-generation, and each spore-capsule a spore-generation.

Egg - generation of Moss. Although mosses are closely wedded to damp surroundings, they can stand a large amount of desiccation without being killed. But it is in the wetter parts of the year that they are in their prime, and we shall then find that groups of egg - organs and sperm-organs are developed at their tips, sometimes associated and sometimes not. In hair-mosses (*Polytrichum*) the ends of certain plants present aggregates of red or orange - coloured leaves [**204**]. If we dissect one of these so-called "flowers of moss," a group of sperm - organs will be found, each of which is a club-shaped structure [**205**], within which numerous motile sperms are produced. At the time of maturity the sperm-organ is forced open by the swelling up of mucilage, and the sperms make their escape. They swim about in the moisture, clinging to the moss—to them an ocean—in search of egg-cells to fertilise.



204. HAIR MOSS **205-8.** MOSS (details) **209.** MARCHANTIA **210.** PLAGIOCHILA

Flask-shaped egg-organs [**208**] are produced at the tips of other moss-plants, or on the same plant, and in each of these is an egg-cell. By the expansion of slime a passage is opened down the neck of the flask, and, as in the fern, this slime exerts a chemical attraction upon sperms. If one of these microscopic bodies succeeds in finding its way down to the egg-cell it fuses with, and thus fertilises it. The fertilised egg-cell now actively develops to form the spore-generation or spore-capsule.

Spore-generation of Moss. The young spore-capsule develops within the egg-organ, which at first keeps pace with its growth [**207**]. Ultimately, however, it is ruptured, and its upper part is carried up as a sort of extinguisher-shaped cap (*calyptra*) upon the capsule, which may be seen as a large fibrous structure in hair-moss. The spore-generation never attains an independent existence, but remains embedded as a sort of parasite in the egg-generation. The capsule which it bears is of very different size, shape, and structure in different species. Within it numerous dustlike spores are produced.

Dispersal of Moss-spores. The top of the ripe moss-capsule falls off, and the opening exposed is bounded by an elegant arrangement of tooth-like strips, the tips of which are sometimes attached to a central membrane. But, in any case, the arrangement is very sensitive to moisture. Wet weather is unfavourable for the wide distribution of the spores by the wind, and the teeth are then closely opposed. But on a dry warm day they curl up, leaving spaces between them, through which the spores escape. If a moss-spore reaches a suitable damp spot it will germinate, giving rise tc branching green threads (*protonema*), upon which new moss-plants are produced as buds [**208**].

We thus summarise the life-history of a moss, placing the more important generation first:

Egg-Generation		Spore-Generation
Moss-plant	Sperm-organ—sperm Egg-organ —egg-cell	Fertilised egg-cell— Spore Capsule—spore

Continued

THE PROBLEM OF HEREDITY

The Nature of Heredity and its Physical Basis. Darwin's Theory of Pangenesis. Continuity of Generation. Galton's Law

Continued from page 1181

By Dr. GERALD LEIGHTON

HITHERTO, in our study of the problem of organic evolution, we have concentrated our attention upon the aspect of variation and selection. But we cannot fail to have been impressed with the fact that at the bottom of the whole problem there lies the question of *heredity*. Variation and heredity are the foundations of all theories of the origin of species of plants and animals, and to the study of heredity we now turn.

Importance of Heredity. Dr. Archdall Reid, in a most telling passage, thus describes the importance of this study. We quote it in the hope that we shall thus secure in this course the careful attention to this subject of a large number of readers and students.

"No kind of study can be made to bear intellectual fruit of nearly such value as the study of heredity. It lies at the root of every science and every study connected with life, from botany and zoology to medicine, sociology, or pedagogy. Who knows it not knows not life except in its superficial aspects. He may be a student of philosophy or a worker in biological science, but in these days, when heredity enters so much into philosophy and links together so many biological sciences, he cannot be a very effective thinker or worker. It furnishes a master-key to the more tremendous events of history, and is our only hope against disasters that loom great and terrible in the near future. It goes deep down to the springs of human life and thought and conduct, and explains why some nations are inheriting the earth and the fruits thereof while others are dying physically and mentally. The philanthropist must know something of this science, or he will grope in the dark. The statesman must know something of it, or he may labour in vain. Transcending all else in importance is the educational value of heredity. No nation in which a knowledge of it was widespread could possibly be stupid or brutal. The habits of thought which must be brought to its study are exactly those which counteract the tendencies which have plunged so many races into their dark ages. So few are the essential facts of heredity, but so prolonged, close, and accurate must be the reasoning founded on them, that no great strain is placed on the memory while the reflective faculties are exercised in the highest degree. So largely would the student's learning link up with the subsequent experiences of his whole life that little would be forgotten, and a sure foundation would be laid for a clear and wide intellectual outlook." If such be the promise and such the reward of the study, who will be found refusing to enter upon it ?

What is Heredity ? No question in the whole world of biology is exciting such interest at the present moment as this one. Numbers of investigators are at work endeavouring to supply the complete answer, which will include the explanation of the actual nature of the phenomenon as well as the statement of the laws which govern its operation.

Obviously, in our study of the subject here, the very first thing to be done is to have a clear and exact mental conception of what the term "heredity" means. This is by no means so simple as might be thought. The word has passed into popular language and writings, and is used in such a vague and ambiguous manner by all and sundry that it is not easy to gain a scientific conception of its meaning. It is a commonplace of expression that such and such a condition or characteristic is "hereditary." What do we mean *exactly* by that ? What is heredity ? Sometimes it is called a *force*, sometimes a *principle* ; it is neither the one nor the other. It is a name applied to a quality or property which is passed on from one generation to the next in succession, a property by means of which the characteristic features of an organism, and even minute details, are enabled to appear again in the offspring. It is the only way in which the present generation of a race is related to that which preceded it, and it is the only way in which the next generation will be related to this one. The relationship is in virtue of this property alone.

In a word, heredity is the name applied to the *relation which exists between successive generations*. Professor Arthur Thomson puts it thus : "Heredity is a term for the relation of organic or genetic continuity which binds generation to generation. Similarly, inheritance may be defined as all that an organism is, or has, to start with, in virtue of its genetic relation to its parents and ancestors." We understand, then, by the word heredity that property of germ-cells in virtue of which certain qualities, traits, or characters which were present in parents or ancestors, are transmitted or enabled to reappear in subsequent generations or offspring. The adjective "hereditary" is a term applied to any quality which is thus transmitted or which thus reappears.

The Basis of Heredity. The next question which suggests itself is, What is the physical basis of heredity ? In what part of an organism does this property lie ? The answer is quite obvious in the light of the above definitions of heredity. The property must be one which pertains to germ-cells, because these alone are concerned in producing new generations and individuals. The study of heredity, therefore, must ultimately centre round the structure and functions of the germ-cells. A germ-cell may, therefore, be compared to an individual to whom a fortune has been left in trust for future inheritors. The fortune is the inheritance of qualities derived from pre-existent generations. But in this case the germ-cell is not only the inheritor but the inheritance.

Now, in order to gain anything like a clear insight into the processes of heredity, it is absolutely necessary, as Dr. Beard has pointed out, that an uninterrupted and continuous panorama of the whole course of development from one generation to another should be secured. This is obvious. It is impossible to see the course of events unless we see all that happens between one generation and the next. The essential idea in heredity is continuity, and, therefore, to see its course, we must find out what there is which is continuous from one generation to the next—physically continuous, that is, so that heredity may be possible.

Continuity of Germ-cells. Heredity must be dependent on some sort of germinal continuity. The very fact of there being such a phenomenon as heredity proves that some physical continuity exists between *the cells* which produce one generation of individuals and the cells which produce the next generation. The germ-plasm from which we sprang was continuous with that from which our parents came, and that with the germ-plasm of our grandparents, and so on backwards and backwards, and still backwards—how far? Think! Back through the ages the thought takes us without the possibility of a break in the continuity, until we come in mental conception to the first germ-cell that ever existed—the first appearance of living protoplasm which was able to produce another piece like itself. Is there any more wonderful and marvellous thought in the whole realm of science? Is it any wonder that variation is a universal phenomenon? When we consider the long line of ancestry of every individual, we no longer wonder that he differs from every other, even from his closest relations; the possibility of variation is so immense, even if it were restricted to all the ancestral characters, to say nothing of the tendency of germ-plasm to vary in new directions.

A Double Inheritance. If we leave out of account the asexual modes of reproduction seen in lowly organisms and in parthenogenesis, and restrict our line of thought to what obtains in higher animals, it will be apparent, of course, that the inheritance of any animal is a double one, coming partly from the father's and partly from the mother's line. It does not follow that the respective portions from each side can always be recognised in the offspring; sometimes they can, sometimes they cannot. Moreover, though we speak of the inheritance as being from the two parents, it is really from the ancestors as well, because of the continuity of the germ-plasm, and it is because of this continuity that every now and then some trait appears which was seen in neither parent, but occurred in some previous generation, possibly in a very remote ancestor. As to which particular characters will appear, and which will not, in any given germ-cell which is fertilised, that is a question which is probably determined at the time of fertilisation, or soon afterwards, by some form of selection.

But let us endeavour to secure the panorama suggested by Dr. Beard as essential to clearness of thought on the matter. How can we construct a picture to show the whole course of development from one generation to another? If we can, this will show the line of heredity—the track along which it works. It must be possible, of course, in order that the features of one animal may be reproduced in its offspring. There must be some cell, or cells, which are actually continuous, or which pass from one generation to the next, or which give rise to new cells in the next, thus reproducing the original characters. The necessity of this has long been recognised, and has resulted in some curious attempts to construct the desired panorama.

Darwin's Theory of Pangenesis. We may note briefly in passing the effort Darwin himself made to answer this question to his own satisfaction; how he tried to construct the necessary panorama of continuous cells from one generation to the next.

In a letter to J. D. Hooker, Darwin expresses his relief at the forming of his theory "from having during many years vainly attempted to form some hypothesis. When you or Huxley say that a single cell of a plant, or the stump of an amputated limb, has the potentiality of reproducing the whole, or diffuses an influence, these words give me no positive idea; but when it is said that the cells of a plant or stump include atoms derived from every other cell of the whole organism, and capable of development, I gain a distinct idea. . . . Therefore, I fully believe that each cell does *actually* throw off an atom, or gemmule, of its contents; but, whether or not, this hypothesis serves as a useful connecting link for various grand classes of physiological facts which at present stand absolutely isolated." Again, in another letter, he says: "It often appears to me almost certain that the characters of the parents are 'photographed' on the child, only by means of material atoms derived from each cell in both parents, and developed in the child."

Darwin's theory of heredity by pangenesis is contained in the words quoted. According to this view, the various body-cells were supposed to give off small portions of themselves, characteristic portions, which in some manner became incorporated in the reproductive tissues. In this way the reproductive cells were supposed to contain samples from all parts of the body, and were thus able, when they developed, to reproduce an organism like the parent. The view involved the belief that the germ-cells were formed by each individual for the next generation. The theory is of interest in the history of the subject, but has now been entirely given up, as it is absolutely unsupported by the facts of embryology since discovered.

The Formation of the Germ-cells. Until quite recently all the world believed, as Darwin did, that the germ-cells which are the basis of heredity were formed in some way or other by the individual. It is still the popular idea. It is none the less an entire fallacy. The most striking fact which has been established by modern embryological research is that *the germ-cells are formed at a very early stage, before the appearance of any trace of an embryo.* This is the essential point of the whole problem. As long as it was supposed that an animal had in some way to make its own germ-cells before it could have offspring, there was endless difficulty in understanding how these cells could get the parental characters impressed upon them in order to hand them on. Hence, arose theories like that of pangenesis. But the great discovery of modern embryological science has been the continuity of germ-cells. The germ-cells do *not arise from the embryo or the adult; they precede the embryo.* No embryo, or individual, in other words, forms the germ-cells for the next generation; they are formed directly from the preceding germ-cells before any sign of an embryo appears at all.

The Course of Development. What happens, then, in the development of the fertilised ovum may be briefly summed up in the following statements, which are taken from the writings of Dr. Beard, the distinguished embryologist of Edinburgh University. It is essential that these few facts be clearly grasped in order to understand and appreciate all the facts of heredity now known.

(*a*) The primitive germ-cell, as the result of its division after fertilisation, gives rise to a number of primary germ-cells.

(*b*) One of these latter (primary germ-cells), and one only, is concerned in forming the embryo. This one is, to all appearance, like the others, an apparent identity all-important from the point of view of heredity.

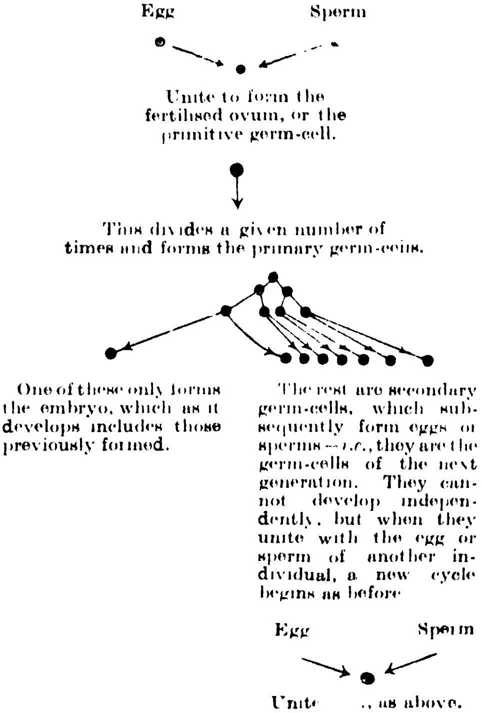
(*c*) The remaining primary cells, which are present in the fully developed embryo, give rise to secondary germ-cells, which are not capable of independent development, but which go through the various processes which result in the formation of eggs and sperms.

(*d*) These eggs and sperms in their turn unite with sperms and eggs of other individuals, and a new cycle of development begins.

Here is our panorama, continued from one generation to the next, showing clearly the line of heredity, which is the line of ancestry, from and through the germ-cells, and never from or through the embryo. Thus there is a real sense, as Mr. Galton says, in which the child is as old as the parent, for when the parent's body is developing from the fertilised ovum, a residue of unaltered germinal material is kept apart to form the reproductive cells, one of which may become the starting-point of a child.

Part of the germ-plasm of the parent egg-cell is set aside from the beginning to form germ-cells for the next generation, and these portions are set aside first, as being the more important part of the whole business, before the development of the embryo begins at all. Thus, *no embryo forms germ-cells*—the germ-cells are formed first. The parent is, therefore, simply the trustee of the germ-plasm, not in any real sense the producer of the child. In a new sense, the child is a chip of the old block. Therefore, of course, like begets like; it could not do otherwise.

Continuity of Generation. To most of us this is a new thought. It is, as a matter of fact, not long since these facts became known, and many who take a general interest in science have not yet grasped them; but it is quite apparent that a simple recognition of these recent discoveries in embryology gives an entirely new aspect to our ideas of heredity, and accounts for much which has hitherto seemed wrapped in deep mystery. So important is it to thoroughly understand this panorama of generations, that it may, perhaps, be well to try to reproduce the idea in graphic manner. The continuity from one generation to the next may be stated thus:


Egg
Sperm
Unite to form the fertilised ovum, or the primitive germ-cell.
This divides a given number of times and forms the primary germ-cells.
One of these only forms the embryo, which as it develops includes those previously formed.
The rest are secondary germ-cells, which subsequently form eggs or sperms—*i.e.*, they are the germ-cells of the next generation. They cannot develop independently, but when they unite with the egg or sperm of another individual, a new cycle begins as before
Egg
Sperm
Unite ., as above.

Thus we see that the line of ancestry and heredity is through the germ-cells alone, and never through the embryo or individual. The embryo appears as a sort of side issue, as far as the line of heredity is concerned. Instead of the individual interrupting the line of heredity, as was formerly thought to happen—*i.e.*, when it was thought that the individual *produced* the germ-cells—we now see that the production of an embryo makes no difference as far as heredity is concerned, except in so far as the germ-cells come to lie within it.

The Real Facts of Heredity. The contrast between the two views—the old theory and the new fact—is as follows:

THE OLD THEORY OF THE LINE OF HEREDITY	THE REAL FACTS OF THE LINE OF HEREDITY
Parent Individual.	An original germ-cell,
↓	↓
Produces germ-cells—*i.e.*, eggs, or sperms.	which, on being fertilised, produces *more germ-cells* (one of which, and one only, can become an embryo and develop into an individual).
↓	↓
These being fertilised, produce an embryo, which in its growth produces germ-cells at some period before it becomes in its turn a	These germ-cells, which are included in the embryo, remain until they in turn become fertilised, when they produce another generation of germ-cells (one of which develops into an embryo).
↓	
Parent individual again.	
↓	↓
etc.	etc.

On the old view it was, of course, impossible to account for the facts of heredity. None could explain how the characters of the parent came to be impressed, as it was called, upon the child. Hence theories like that of pangenesis. But now that we know that germ-cells never arise except from germ-cells, that they are never produced by the individual, that they are simply continuous with pre-existing germ-cells, it becomes quite easy to see why the main characters of a race are always very much alike, and how a character once appearing in the germ-plasm is transmitted to generation after generation.

In the above statement of the case, we have, for the sake of simplicity, assumed that we are dealing with a vertebrate which has only one embryo at a birth. The case of twins or plural births need not be represented, as it does not affect the present point. The clear demonstration of this panorama from generation to generation is the brilliant result of years of research on the part of Dr. Beard, of Edinburgh University, to whose writings we must go for the details of the subject.

"The likeness of all the primary germ-cells is certain, or almost so; absolutely nothing suggests unlikeness among them. This essential identity, or equivalence, of all the primary germ-cells is immensely important from the point of view of heredity. . . . It is it, and it alone, which permits of the handing down of the characters of one generation to future generations. It is the very basis of heredity. The formation of like primary germ-cells and their essential similarity, or equivalence, show how, in sexual reproduction, the offspring resemble their parents while differing from them. The likeness in the primary germ-cells leads to likeness in the offspring, and along with this unlikeness is bound to come in. For the primary germ-cells themselves give rise to secondary germ-cells, which have lost their power of independent development. It is these, and these only, as a rule, which are present in the finished embryo. They and their progeny are never capable of normal independent development (in the vertebrata); but it is their destiny to go through the process of the reduction of chromosomes, with the ensuing formation of sexual products, or gametes, eggs, and spermatozoa. Here, as is of course now generally recognised, unlikeness enters."

We need not follow these fascinating researches further, our present purpose being to gain a clear idea as to the actual basis of heredity and the course of its path from one generation to the next. We must now pass from one phenomenon itself and glance, as far as space will allow, at the efforts which have been made to discover the laws which govern its operation. We can do no more than merely state these here. Their discussion would involve a large volume.

Galton's Law. It is to Francis Galton that we in this country owe the collection and arrangement of an enormous mass of facts on heredity, and his example has been followed by a number of other workers from various points of view. The observations and calculations from which we deduced what is known as "Galton's Law of Ancestral Heredity" were obtained from the registered colours of a pedigree stock of basset hounds. These hounds, originally purchased by Sir Everett Millais, resulted, after years of breeding, in a collection of 817 hounds of registered colours, descended from parents whose colour is also known. In 567 cases the colours of all four grandparents are known; and of these, in 188 cases the colours of all eight great-grandparents are also known. The calculation from these facts is in the original paper read before the Royal Society, on June 3rd, 1897, and the law itself may be stated as follows.

Galton supposes that of its total heritage the individual receives from its two parents one-half, from the four grandparents one-fourth, from the eight great-grandparents one-eighth, from the 16 great-great-grandparents one-sixteenth, and so on in series, the sum of the total contributed heritages being equal to one. The law is thus a statement of the average contribution of each several ancestor to the total heritage of the offspring. The two parents between them contribute on the average one-half of each inherited faculty, each of them contributing one quarter of it, and so on as above stated.

The most obvious criticism which has been directed to this law is that the theory demands that there is an absence of relationship among all the ancestors, in fact, that there shall be no inbreeding.

Professor Karl Pearson has since formulated a modified statement of this law.

Continued

BILLS RECEIVABLE

Negotiability. Endorsement. How to Date a Bill. Bills Payable and Bills Receivable. The Bill Book. Discounting

Continued from page 1080

By A. J. WINDUS

TRANSACTION (*m*) will be dealt with immediately after (*n*).

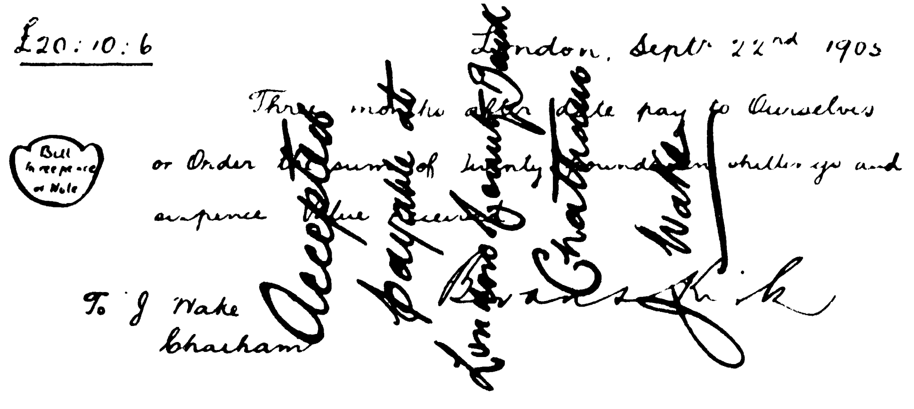
Sept. 26th. Received and discounted J. Wake's acceptance for £20 10s. 6d., the bank charging 3s. for discount.

Into this brief sentence is compressed the narrative of three events, all occurring on the same day, but distinct from one another.

1. Receipt by Bevan & Kirk of acceptance from J. Wake.
2. Sale of acceptance by Bevan & Kirk to their bankers.
3. Charge for interest by Commercial Banking Co. against Bevan & Kirk.

Let us carefully consider these three events. First, let us try to understand their total, or combined effect; then let us study each event separately.

Referring back to (*i*), we there find the original proposal made by Bevan & Kirk as to payment of amount due from Mr. Wake. It is true the proposal was couched in peremptory language, but that was necessary in order to comply with the Bills of Exchange Act 1882, which defines a bill of exchange as an unconditional *order* in writing. None the less is Mr. Wake at liberty to decline Messrs. Bevan & Kirk's proposal, and if he so declines, there is no agreement—no contract; consequently there is no transaction capable of being recorded in terms of double entry. But Mr. Wake has accepted Bevan & Kirk's proposal, and in the result we have the completed mercantile contract as shown hereunder:



£20:10:6 London, Septr 22nd 1905

Three months after date pay to Ourselves or Order the sum of twenty pounds ten shillings and sixpence value received

To J Wake
Chatham

Bevan & Kirk

Accepted
Payable at
London & County Bank
Chatham
J Wake

When the bill was first issued, it was called a *draft*, because it was "drawn" by Bevan & Kirk on their debtor. But from the moment that it was "accepted" by the drawee (J. Wake) it became known as an *acceptance*, and a new name, *acceptor*, was conferred upon the drawee. With the document in their hands, are Bevan & Kirk any better off than they were before? Undoubtedly they are. In the first place, they have the debtor's written engagement to pay the debt within a definite period, and since this engagement is contained in a bill of exchange the amount of the debt is no longer open to question. The debtor is bound to pay it without dispute at maturity of the bill.

Negotiability. Further, the acceptance is a negotiable instrument. What this means may be partly inferred from the fact that on the same day as they received it Bevan & Kirk disposed of it to their bankers, who gave credit for it in account, at the same time charging 3s to Bevan & Kirk for discount.

That quality or property of bills of exchange which enables them to be bought and sold as readily as tea and sugar is termed negotiability. This property belongs to other instruments besides bills—to promissory notes, for instance, and to cheques, dividend warrants, etc. Cheques, however, are frequently marked "not negotiable," a somewhat misleading term for the unwary. It may be advisable, therefore, to return to the subject of negotiability at a future stage. For the present, let us note that when an instrument is negotiable, the title thereto passes by mere delivery, or by endorsement and delivery, and the holder who has come honestly by it has all the rights and none of the disabilities of previous owners.

We may apply these rules to the case before us. The acceptance by Mr. Wake, due three months hence, has in effect extinguished the present claim of Bevan & Kirk against their customer, because neither they nor anyone else can demand payment until the bill falls due. From the point of view of Mr. Wake, this is a very convenient arrangement, as it gives him time to sell the goods he purchased from Bevan & Kirk before being called upon to pay for them. This is, indeed, one of the uses of credit whereby business men are able to trade on a comparatively small capital.

Wholesale and Retail Firms. Let us see how the wholesaler or the manufacturer fares under this system. With Bevan & Kirk bill transactions are the exception rather than the rule, most of their customers preferring to pay promptly for the sake of the cash discounts, but in many wholesale and manufacturing businesses (hardware and machinery, for example) bills are the recognised medium for the settlement of accounts. When, on the one hand, a great many sales are effected on long credit—three months, four months, and sometimes six months—and, on the other hand, purchases must be paid for within thirty or forty days from invoice dates, while a large sum is paid away every week in wages, it is evident that, apart from outside aid, even concerns of the very first magnitude must occasionally find themselves uncomfortably near the end of their cash resources.

But take a smaller business by way of illustration. The bank balance of the Gourock Hardware Company, Limited, on December 1st last, was £153 14s. 6d. The company usually allows four months' credit for goods sold, taking bills in settlement. August, however, was a very slack month. The total sales for the month did not exceed £4,000, which represents the maximum amount receivable by the company in December, when the August acceptances mature. But in December the factory is running full time, and wages have to be provided for at the rate of £500 a week. Purchases to the extent of £2,500 must also be paid for if advantage is to be taken of discount terms offered by the sellers. We may summarise the position thus: The bank balance on the first day of December is about £150, and it is assumed that during the month £4,000 additional will be received. That is to say, £4,150 in all will be available for the payment of purchases and wages, together amounting to not less than £4,500.

Current Liabilities. The company therefore resort to their bankers, who agree to purchase £1,000 worth or so of current acceptances recently received by the company from their customers, provided the company will guarantee their due payment at maturity. With this assistance the company can pay its way in December, at all events, or, as the secretary would express it, his company is "able to meet current liabilities as they arise." Traffic in bills of exchange is practically confined to bankers and bill brokers, and already, perhaps, we begin to perceive in some dim fashion that the banker is a very useful link in the chain of commerce which encircles the globe and binds the nations together.

Returning to transaction (*a*), we shall see that what the Hardware Company did on a large scale, Bevan & Kirk have done on a smaller one. On receiving Wake's acceptance, they sell it to the bank for its full face value of £20 10s. 6d., and this amount is at once placed to their credit in the bank ledger. Thus Bevan & Kirk get their money quite three months before they can legally demand it of Wake. Virtually, their bankers have paid the debt on J. Wake's behalf, so that the acceptance now becomes the bank's property, and when it falls due the acceptor will have to pay the bank and not Bevan & Kirk. But how is Wake to know that he will be doing right in making payment to the bank instead of to his creditors, Messrs. Bevan & Kirk? The answer is that he is bound to pay the holder of the bill who presents it for payment at maturity, no matter who this may be, unless he has reason to suspect some flaw in the holder's title. Accordingly, when the day of reckoning comes, he pays that person who actually shows him the acceptance he originally gave to Bevan & Kirk—that is, who "presents it for payment." The payee thereupon delivers up the bill to the acceptor, thus putting an end to Wake's liability in respect thereof.

Endorsement. There is a very important formality connected with the transfer of the bill from Bevan & Kirk to their bankers, which must not be overlooked—namely, endorsement. Before Bevan & Kirk sent Wake's acceptance to the bank, they endorsed it, which means that they signed the firm-name on the back. Now a bill of exchange is oblong in shape, and custom has decreed that endorsements thereon shall be at right angles to the writing on the other side. Moreover, the first, or only endorsement, should be at the top of the paper rather than in the middle or at the bottom; and then other signatures, if any, may follow in the order in which they are endorsed.

Perhaps it may be useful to give a simple rule for ascertaining which is the top of a bill or cheque for the purpose of endorsement. Take the top left-hand corner of the document between the left thumb and forefinger, the latter being underneath, and turn the paper over in such manner that the positions of the thumb and forefinger are reversed, but so that the forefinger shall still be at the top left-hand corner. This can be done by a single turn of the wrist, and its effect will be to bring the paper into the proper position for endorsement. The subject of endorsements will be considered more in detail later, but the important point to remember is that an endorsement operates as a guarantee by the endorser that the acceptor will pay the bill at maturity.

The endorser is really a surety for the principal debtor, the acceptor, so that if for any reason the acceptor dishonours the bill, the holder would look to the surety or endorser for payment.

The Bank's Charge for Discount. We have seen that J. Wake's acceptance was purchased by the bank—that is, the bank has bought the right to receive from J. Wake in three months' time the sum of £20 10s. 6d. This right originally belonged to Bevan & Kirk, who sold it to the bank. For how much? Nominally for its full face value, but actually for something less. Examining the transaction again, we notice that the bank charges 3s. for discount, which represents the value of the benefit derived by Bevan & Kirk from having the bill paid now instead of three months hence. We observe that the discount rate is 3 per cent., and this information will enable us to test the correctness of the bank charge. But first we must discuss the due date of the bill.

Dating a Bill. What the Bills of Exchange Act has to say as to the computation of the time of payment is to be found in the fourteenth section. The section states that where the bill itself does not otherwise provide, and unless it is drawn payable on demand, the time of payment as fixed by the bill is extended by the addition of three days of grace, and the bill is payable on the last day of grace. But "when the last day of grace falls on Sunday, Christmas Day, Good Friday, or a day appointed by Royal Proclamation as a public fast or thanksgiving day, the bill is . . . . . . due and payable on the *preceding* business day. When the last day of grace is a Bank-holiday (other than Christmas Day or Good Friday) . . . . . the bill is due and payable on the *succeeding* business day. Where a bill is payable at a fixed period after date . . . . the time of payment is determined by excluding the day from which the time is to begin to run, and by including the day of payment. The term 'month' in a bill means calendar month."

We can now, with this as a guide, calculate the due date of Wake's acceptance, which is made payable three months after September 22nd, 1905. From September 23rd to December 22nd there are three calendar months, add three days of grace, and we arrive at December 25th as the day for payment, but since this is Christmas Day, the bill is due and payable on December 23rd, the preceding business day. Now, the argument of the bankers is this. Say they: We paid the amount of Wake's bill to Bevan & Kirk on September 26th, or 88 days before we can obtain the money from the acceptor. We must therefore charge our customers, Bevan & Kirk, interest at the rate of 3 per cent. per annum on the amount of the bill for the whole period during which we have to lie out of our money, and 88 days' interest on £20 10s. 6d., at 3 per cent. per annum equals 3s.

Discount. Theoretically, this contention is a sound one, and unless the total amount of bills under discount is large, it causes no appreciable difference in results. Nevertheless, bankers' discount is not exactly the same thing as true discount, as may be proved from the case of the Gourock Hardware Company, already cited. The Hardware Company discounted about £1,000 worth of acceptances with their bankers at 4 per cent., which, if we allow the average due date to have been three months from date of discounting, would give £10 as the bank charge for discount. The *net* amount received by the company was, therefore, £990, but if £990 were put out at 4 per cent. interest for three months, it would not amount to £1,000 but to £999 18s. only, the difference of 2s. representing the difference between bankers' discount and true discount.

Bills Payable and Bills Receivable. We have now fulfilled our object of studying the combined effect of the three events narrated in (*n*). We have still to record them in Bevan & Kirk's books of account. As so often happens in bookkeeping, two methods of making the original entry are here open to us. The one we shall adopt is perhaps the simpler, but an opportunity of showing the alternative method will not be neglected.

Accountants divide bills of exchange into two great classes—Bills Receivable (B/R) and Bills Payable (B/P), but these terms embody merely a relative truth.

The fact is the same bill may be described by one person as a bill receivable and by another as a bill payable. Its character changes with the standpoint of the persons affected. To Bevan & Kirk, Wake's acceptance is a bill receivable because it represents a sum of money *receivable* by the firm; to Wake himself it is a bill payable because it represents a sum of money *payable* by him. Our concern at the moment, however, is with the books of Bevan & Kirk, and we must therefore regard Wake's acceptance as a bill receivable. Seeing that the bill was discounted on the day it was received there is no real objection to our looking upon it as cash. We treat cheques received as cash because we believe that when they are sent to the Commercial Banking Company by Bevan & Kirk the sums they represent will be speedily collected from the banks on which the cheques are severally drawn, and that the proceeds will be at once credited to the banking account of Bevan & Kirk.

Contingent Liability. In the case of cheques it is always possible that one or more of them may not be met, so that, even though the same element of doubt exists in the case of a bill receivable discounted, that is not a sufficient reason why we should not enter it as a cash item, especially as in the meantime, whatever may be the ultimate fate of the bill, it has been sold to the bank, who have given credit for same in account. Accordingly the entry will be found on the debit side of the cash book (*q. v.*), under date of September 26th.

But we must not entirely ignore the element of doubt just now mentioned. We know that if Mr. Wake fails from any cause to discharge his acceptance on December 23rd, the Commercial Banking Company will require Messrs. Bevan & Kirk to do so in his stead. Some provision must, therefore, be made in the books of Bevan & Kirk, safeguarding them against being taken by surprise by a claim of this sort arising at an inconvenient time. This protection is afforded by the bill book, which, as explained, belongs to the supplementary group of counting-house records. The book, properly kept, may be made to furnish a variety of useful information, as will be seen from the specimen given on next page:

BILLS RECEIVABLE

No.	When received		On whose Account	Place	By whom Drawn	To whose Order	By whom Accepted	Where Payable	Date		Term	Amount			Due												Folio	How disposed of
															Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.		
12	1905 Sept.	26	J. Wake	London	B. & K.	Ourselves	J. Wake	Ldn.&Cty. Chatham	1905 Sept.	22	3 m	20	10	6												23		Discounted 26 Sept.

The Bill Book. All bills should be entered in the bill book, with the particulars called for by the various columnar headings, bills receivable in the section devoted thereto, and likewise bills payable in their own section, which will be exhibited when we study transaction (*m*). A faithful record of all bills receivable would declare their several due dates, including the due dates of those under discount, and it would then be an easy task for the accountant or his principal to run through the bill book at the beginning of each month, taking a note of all bills which require attention; some because, perhaps, they are under discount, and may possibly be dishonoured; others because they, though not under discount, but locked up in the safe, mature some time during the month, and must be sent to the bank in good time for collection.

A further word on bills discounted by the bank. As a rule, no one can be certain until the day of payment arrives whether an acceptance will be paid or dishonoured. Of course, if the acceptor goes bankrupt between the time when he accepted the bill and the due date it is a foregone conclusion that the bill will not be paid in full; but apart from this there is always the *contingency* that the drawer may be called upon to pay the holder of a bill at maturity. If the acceptor pays, well and good; the drawer is released from further liability and the contingency disappears. If, however, the acceptor fails to pay, the contingency is translated into a certainty. Whereas, before there was merely a *contingent liability*, the drawer now labours under an actual liability.

Discounting a Bill. The concluding words of (*n*) are: "the bank charging at the rate of 3 per cent. p.a. = 3s. (see pass book)." We have called this charge Interest in one place and Discount in another. The double description should serve to remind us that what is loss, or discount, to Bevan & Kirk, is gain, or interest, to the bank, the fact being, as we have seen, that the Commercial Banking Company have charged interest in advance on the amount of Wake's acceptance. The method of calculating this interest has been shown; we know also that the operation in its entirety is termed *discounting*, and we may add that when we speak of "discounting" the pretensions or promises of individuals we are borrowing the language of Finance. To discount is to take something off the count. It is clear that this has been done with Wake's acceptance, because, while the bankers have credited the full amount to Bevan & Kirk's account, they have at the same time debited 3s. thereto, and the net result is that Bevan & Kirk receive credit for £20 7s. 6d. only. Failing a special application to the bank, Bevan & Kirk have no intimation as to the amount of the discount charge until they obtain their pass book on September 28th. Then they find in the pocket of the pass book a debit slip for 3s., along with a number of their own cheques, which, having been paid by the Commercial Banking Company, are now returned cancelled.

Continued

THE DYNAMO

Lap Windings and Wave Windings. How to Join up the Armature-conductors. Self-exciting and Independently Excited Dynamos

Group 10

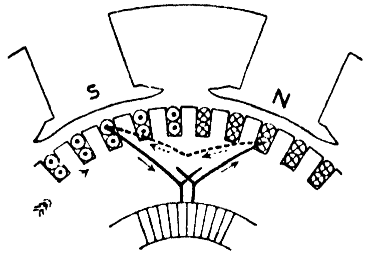
ELECTRICITY

9

THE DYNAMO
concluded from page 1109

By Professor SILVANUS P. THOMPSON

Lap Windings and Wave Windings. We have seen that the proper breadth of each loop of the winding is that it should be approximately equal to the pole-pitch—that is, the arc from the middle of one pole-face to the middle of the next pole-face. We have also seen that the loops should be joined up in a regular series. But there are two modes of doing this, and they lead to slightly different results. These two modes of grouping the coils are termed respectively *lap winding* and *wave winding*. To understand these modes, let us adopt a method of representing a current flowing in a wire. It is easy enough to indicate which way a current flows in a wire by simply drawing an arrow by the side of the wire to point the direction, as was indeed done in the article on batteries [p. 465]. But we need also a way of showing the direction of the current in diagrams that show the section of an armature, where the cross-section of the wire appears merely as a small circle. To indicate a current coming towards us in such a section, we will put a dot in the middle of the small circle ; and to indicate that a current is going from us, we will put a cross in the circle. Now let **65** represent a section of a piece of an armature of a multipolar dynamo that has the windings laid two-deep in slots. Let us suppose this armature to be revolving right-handedly past the poles, as shown by the dotted arrow. Then, by applying the right-hand rule [p. 1105], it is easy to ascertain that the induced currents will be flowing towards us in those wires which are moving past the south pole, and will be flowing from us in those wires which are passing under the north pole. (If the motion were to be reversed, the directions of the currents would, of course, be also reversed.) Accordingly, mark these directions with dots and crosses, as in **65**. Now consider a loop made of two of these conductors by joining their distant ends by an end-bend (shown dotted), their front ends being brought out towards one another. We select as one conductor a wire in the top of a slot under the middle of the north pole, and, as the other, a wire in the bottom of a slot under the middle of the adjacent south pole. This constitutes a typical loop, and we see which way the current will flow around it.



65. HOW LOOPS ARE CONNECTED UP

Successive Laps. Now, the question is, how shall we join up this loop to other similar loops in the other slots? Suppose this machine had been an 8-pole machine, with 40 slots. (A real machine would have a larger number of more slots, but we take this small number as being manageable.) That makes five slots per pole. Then, if the slot under the middle of the south pole be regarded as slot No. 1, the slot under the middle of the north pole will be slot No. 6. There being two conductors in each slot, we may number them as follows. Conductors in the tops of the slots will be called 1, 3, 5, 7, etc., while the conductors of the lower layer in the bottoms of the slots will be even numbers, 2, 4, 6, 8, etc. Our typical loop is made by joining wire No. 1 to wire No. 12. We may make similar loops by joining No. 3 to No. 14, and No. 5 to No 16, and so on. Now, to join the loops together into a continuous winding, the simplest way is to join the end of the first loop to the beginning of the second, the end of the second to the beginning of the third, so that the order in which the conductors are joined up is

1-12-3-14-5-16-7-18-9-20-11, etc.

It will be seen that in this mode of joining *the winding laps back upon itself*, the loop 3-14 overlapping 1-12, and so on. If the series be continued, we go right round the whole lot, and end off as follows : 69-80-71-2-73-4-75-6-77-8-79-10-1.

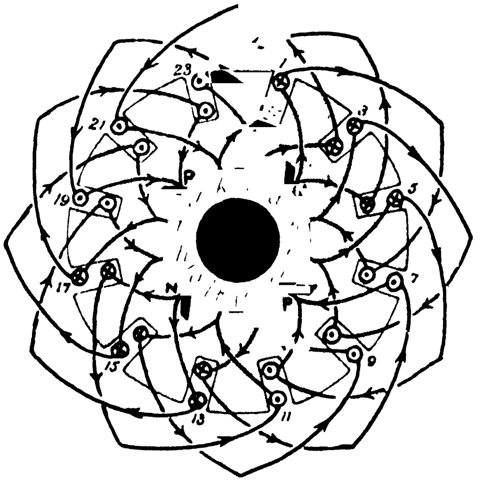
Successive Waves. The other mode of grouping is called *wave winding*. To carry it out we shall need an odd number of slots—say, 39 instead of 40. The first slot will contain conductors Nos. 1 and 2, the last slot Nos. 77 and 78. Now consider the loop made by Nos. 1 and 12. Instead of lapping back to the loop made up of Nos. 3 and 14, connect the winding forward to a loop surrounding the next north pole further on—namely, the loop made up of Nos. 21 and 32—and let this be again joined forward to the loop opposite the next south pole in regular succession. Four such loops will then run as follows : 1-12-21-32-41-52-61-72 ; and this has brought us round not to the slot from which we started, but to the one next to it. It will be seen that the successive steps forward are values of 11 for the front pitch, and of 9 for the back pitch. If we continue on, we should have, after 61-72, the numbers 81 and 92. But there are only 78 conductors in all, so that the 81st is really No. 3, and the 92nd is No. 14 ; so we get for the next round of the series : 3-14-23-34-43-54-63-74 ; and so on until we have gone through the whole set and wind up on the eighth round as follows:

19-30-39-50-59-70-1-12;

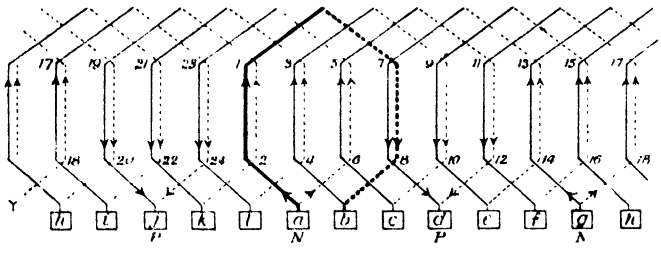
thus ending by becoming re-entrant.

Anyone who wants to become familiar with wave-windings should draw a diagram of these 39 slots around a circle, and join up the conductors in the fashion followed in 68. We shall merely remark that while for a lap winding any number of slots, odd or even, can be used, for a wave winding the number of slots must be odd, and must fulfil the formula $S = py - 1$; where S is the number of slots, p the number of poles, and y the average number of slots of the winding pitch (in the above case $y = 5$).

Paths Through a Winding. It was remarked above that in any re-entrant winding there are necessarily at least two paths for the current. We have next to examine this point more closely. To help us in this let us consider a 4-pole machine such as **44**. The currents in the conductors that are passing under the poles will have directions as already determined by the rule of the right hand. Now consider the winding scheme for a 4-pole machine, as simplified in the diagram [**66**] Here there are supposed to be only 12 slots, with two conductors in each. The four magnet-poles are not drawn, they must be imagined; and we can describe their positions by the respective quadrants they face. But we see that if the four poles stand as in **49**, and if the armature is revolving right-handedly, as in **65**, the induced currents will be flowing towards us in all wires that are passing through the NW and SE quadrants (being marked with *dots*), and will be flowing from us in all wires that are passing through the NE and SW quadrants (being marked with *crosses* in the diagram). Now let these 24 conductors be joined up in a lap winding, taking the back pitch as 7 and the front pitch as 5—that is, No. 1 conductor is joined at the back of the loop to No. 8 conductor—and then let the connection at the front from No. 8 lap back to No. 3. The numbering and connections of the various conductors is perhaps better understood by use of a *developed* winding diagram such as **67**, which represents the same winding as though laid out flat. In the *radial* winding [**66**] all the end-bends of the loops that are at the "front," or commutator, end of the armature, are drawn at the interior, while all the end-bends at the "back" of the armature are drawn at the exterior of the diagram. Now, to both these diagrams [**66** and **67**] let us add arrows to show the directions of flow of the currents. For example, in conductor No. 1, which is in the NE quadrant, the cross in the small circle indicates that the induced current is flowing *from* us. Let us then add arrow-heads on the front end-bends leading to No. 1 in that at the back leading from No. 1 to No. 8. When we shall have similarly marked all the connecting wires, we shall discover that there are four points on the winding to or from which the currents converge. Thus, two currents run to converge *toward* each of the two points marked P (positive), and two others run *from* each of the two points marked N (negative). As shown in both **66** and **67**, the windings are joined at regular intervals by risers to the bars, or segments, of the commutator, marked *a*, *b*, *c*, *d*, etc. A little consideration will show that it is just at these four points marked N, P, N, P, that the brushes must be set to collect the currents. The two positive brushes at PP must be joined together and connected to the positive main of the circuit; and the two negative brushes at NN must similarly be joined to the negative main of the circuit, and it now becomes evident that in this lap-wound 4-pole armature there will be four paths—all "in parallel" with one another—from the negative to the positive side. If the machine were delivering, say, 100 amperes, 25 amperes would flow along each of the four paths. This is one of the properties of a lap winding—*there will be as many paths through the armature windings as the machine has poles*; and there will be needed *as many sets of brushes* around the commutator as the machine has poles.

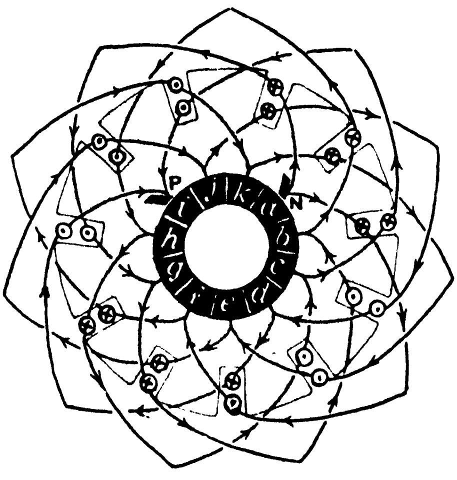


66. LAP WINDING, RADIAL DIAGRAM

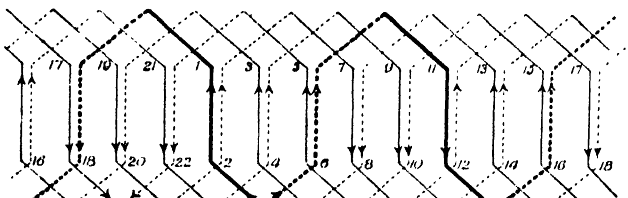


67. LAP WINDING, DEVELOPED DIAGRAM

Series Parallel Circuits. Now turn to the case of the wave winding. The corresponding diagrams are given in **68** and **69**, the former being a radial diagram, and the latter a developed diagram. The number of slots is 11, of conductors 22, and of commutator bars 11. It is still a 4-pole machine, with induced currents coming toward us in the NW and SE quadrants, and going from us in the NE and SW quadrants. The winding pitches back and front are both 5, for No. 1 is joined at front to No. 6, and No. 6 at back to No. 11. If now we think out the directions of the currents, and draw the arrow-heads in all the end-bends, we shall discover that there are *only two* points in the winding where the currents converge—one P (positive) and one N (negative). In this case, therefore, the adoption of a *wave winding* leads to the result that though the machine has four poles, *there are only two paths in parallel through the armature*, and two brush-sets only will be needed, and these must be set at a distance of one pole-pitch apart on the periphery of the commutator. It is a property of a wave winding (if made like this, with one slot fewer than an exact multiple of the number of poles) that *two brush-sets only are needed, whatever the number of poles;* and there will be two paths only through the windings from negative to positive. Such armatures are sometimes called *series wound*, though *series parallel* is more accurate. This kind of winding (using former wound coils like **57**. grouped to form a wave winding) is preferred for tramway motors and for variable speed motors generally. It is also good for such generators as are to give relatively small currents at high voltages. By a modification of the same plan windings can be found which will give either two, four, or six paths through the armature of a multipolar machine.



68. WAVE WINDING, RADIAL DIAGRAM

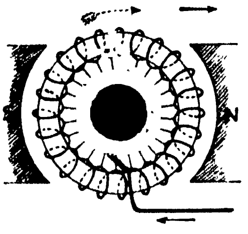


69. WAVE WINDING, DEVELOPED DIAGRAM

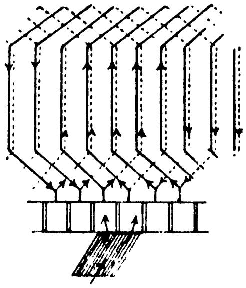
Rocking the Brushes. It will now be evident why the brush-sets must be mounted on an adjustable frame. It is that they may be set at the exact spot, or *neutral position*, where the currents tend to converge. If they are shifted from that spot, the usual effect is an outburst of bright sparks, which are destructive of the commutator. The so-called *rocker* is a clamping frame to procure exact adjustment of position.

Ring-wound Armatures. Earlier in date than either the lap-wound or the wave-wound toothed drum armatures were the ring-wound armatures of Pacinotti (toothed ring, 1864) and of Gramme (smooth ring, 1870). In both these the wires were coiled on a ring-core, the wire being wound on the ring in sections, and each section being joined up to the next, so as to make a re-entrant winding. This winding was connected down at regular intervals to the segments, or bars, of a commutator. The scheme is shown diagrammatically in **70**. In fact, though the separate coils do not overlap one another, the winding progresses regularly around the ring, and precisely resembles in its properties a lap winding, save that each turn of the winding threads back through the interior of the ring. This prevents the use in ring-wound armatures of former-wound coils. The commercial introduction of the Gramme ring gave an immense impetus to the infant industry, but ring windings are never now used, except in quite small machines and little motors. The bipolar lap-wound drum winding was due to Von Hefner, in 1872.

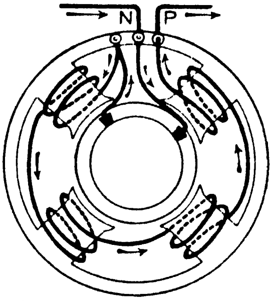
Sparkless Commutation. If attention be directed to individual loops of the winding it is seen that as they pass along under successive poles the currents induced in them are continually reversing in direction. The reversal takes place as the slots containing the sides of the loop have passed away from being under the poles and are just coming again under the tips of the next pair of poles. This is the moment when the corresponding bars of the commutator are passing by the collecting brush. As the brush is generally broad—broader than the breadth of a commutator-bar—it follows that at the time when the brush makes contact with two bars of the commutator at once the coil, or loop, whose ends are joined to those two bars will be short-circuited. If the brush be broad, the duration of this time of short circuit will be longer than if the brush be narrow. Now, it takes time for a current in a loop to be reversed in direction, for the current has to die down and then grow again, flowing in the opposite sense. Broad carbon-brushes give the necessary time for this operation, and the resistance of the film at the surface of contact acts like a valve-port of varying size to turn the current off and on again in the loop. Thus the resistance at the face of a broad carbon-brush affords a means of *natural commutation* without sparking. But if the current to be collected is too great, or if there is not time enough allowed in the brief duration of the passing contact, and if metal brushes are used, then resort must be had to *forced commutation*. By this term is meant the introduction into the loop or coil that is undergoing commutation of induced electromotive forces that tend to *force* the current in it to reverse during the time of contact with the brush. Such forced commutation is effected in one of two ways. The oldest way is to rock the brushes to a position *forward* from the neutral point, so that the coil, or loop, is actually beginning to cut the magnetic lines during the time of brush contact. The newer mode is to provide *auxiliary poles*, called reversing poles, between the ordinary poles of the field-magnet.



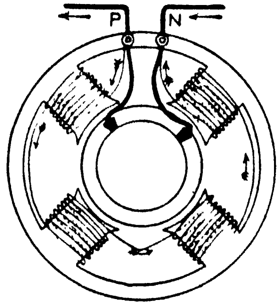
70. RING WINDING



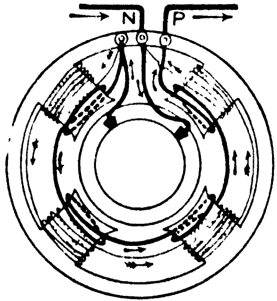
71. THE ACT OF COMMUTATION



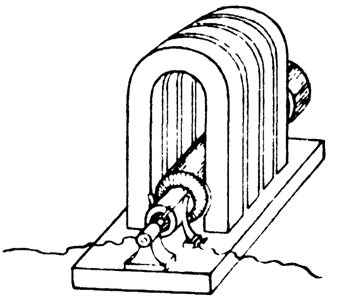
72. SERIES EXCITATION



73. SHUNT EXCITATION



74. COMPOUND EXCITATION



75. MAGNETO

Calculation of a Dynamo. The electromotive force of a dynamo depends on the strength of the magnet-poles, the number of conductors on the armature, the speed and the grouping of the windings, and is readily calculated as follows. Let N stand for the number of magnetic lines that any one pole—all the four poles should be equally strong—sends across the air gap to the armature—that is to say, the amount of magnetic flux per pole. This will be usually some number between 1,000,000 and 20,000,000. Let p stand for the number of poles. Let c stand for the number of circuits, or paths, through the windings (2, in wave-wound armatures, or as many as p in lap-wound armatures). Let Z stand for the number of conductors all round the armature, this being the same as the number of slots multiplied by the number of conductors per slot. (In actual machines this number is seldom under 80, and seldom over 1,200.) Lastly, let the number of revolutions per minute be called RPM, so that the number of revolutions per second will be RPM ÷ 60. Then it is clear that the number of poles passed in a second by any one conductor will be equal to $p \times$ RPM ÷ 60; and the number of lines cut per second by any one conductor will be equal to $\mathrm{N} \times p \times \mathrm{RPM} \div 60$. Now, as already stated in ELECTRIC MEASUREMENT, one volt is equal to the cutting of 10^8 (*i.e.*, 100,000,000) of lines per second. Hence, the number of volts generated in one conductor of the armature will be $\mathrm{N} \times p \times \mathrm{RPM} \div (60 \times 10^8)$. But there are (Z) conductors, and these are all joined up together in a particular way so that they constitute (c) circuits or paths, and the number in series in each circuit or path will be $\mathrm{Z} \div c$. Hence, if we multiply the volts generated per conductor by this number we find an expression for the whole voltage (E) generated by the machine. So we write

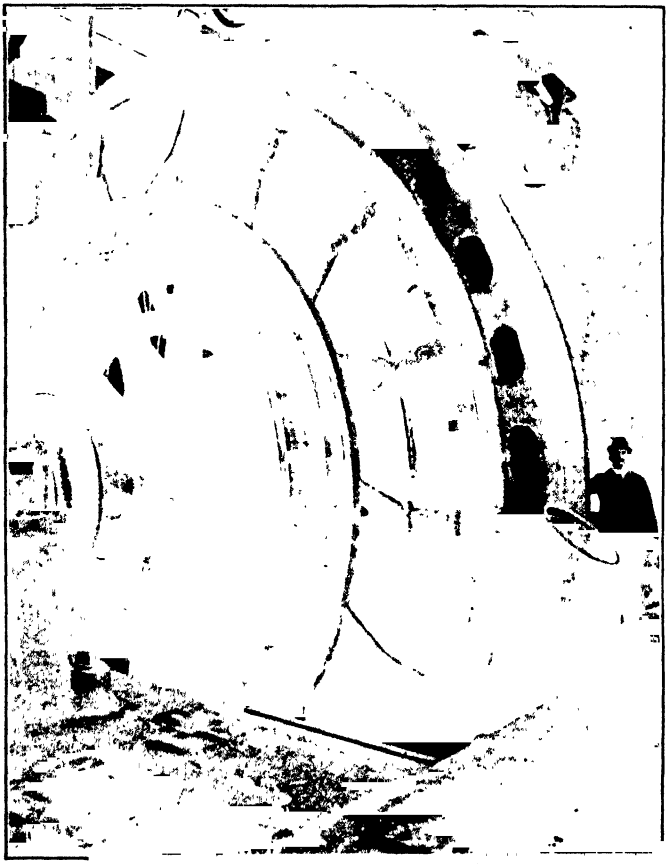
$$\mathrm{E} = \frac{p}{c} \times \frac{\mathrm{RPM}}{60} \times \mathrm{Z} \times \mathrm{N} \div 10^8$$

For example: In the dynamo depicted in **44**, $p = 4$; $\mathrm{N} = 2{,}700{,}000$; $c = 2$; $\mathrm{Z} = 444$; $\mathrm{RPM} = 640$. Making the calculation, we have:

$$\mathrm{E} = \frac{4}{2} \times \frac{640}{60} \times 444 \times 2{,}700{,}000 \div 100{,}000{,}000 = 256$$

volts.

Excitation of Magnetism. There are several ways of exciting the magnetism of the magnets of dynamos. In the early magneto-electric machines of Faraday the magnets were either permanent magnets, of hard steel, or else soft iron electromagnets, separately excited by means of batteries. In 1851 Sinsteden suggested using the current from a small permanent magnet-machine to excite the electromagnets of a larger machine. In the years 1866–7 several inventors—amongst them Wheatstone, Siemens, and Varley—independently proposed to render machines self-exciting by passing either the whole or a part of the current from the armature around the field-magnets. About twenty years later compound winding was introduced. Figs. 72, 73, and 74 show respectively schematic diagrams of the connections of the magnetising coils in a *series-wound* dynamo, in which the exciting coils receive the whole current, and are in series with the outside circuit; a *shunt-wound* dynamo, in which the exciting coils receive a small fraction only of the whole current, being of fine wire, and are in shunt with the external circuit; and a *compound-wound* dynamo, in which shunt coils give the principal magnetisation, while some series coils serve to increase the magnetisation as the load in the external circuit increases.



76. COMMUTATOR END OF 2,700-KILOWATT 36-POLE DYNAMO, AT BOSTON, U.S.A.

Series-wound dynamos are very inconstant in their voltage, since this depends on the magnetism, and the magnetism will vary with the load, being very small at small loads, and large at full load.

Shunt-wound machines are very nearly constant in their voltage at all loads, as the magnetism is practically constant, and the voltage-drop at full load, due to reactions and internal resistance, may be less than 2 per cent. of the initial value.

Compound-wound machines are constant in their voltage at all loads, or may even be made—by increasing the number of series coils—to cause the voltage to rise at times of full load. Such over-compounding is useful in tramway generators.

Magneto-electric Generators. Little machines with permanent magnets of hard steel are still employed to generate currents on a small scale, as toys, and for ignition purposes in automobiles. In such cases **[75]** the magnets are bipolar horseshoes, the armature is reduced to the simple shuttle-form invented by Siemens in 1855, and the commutator shrinks back to the primitive form of a bit of copper tube split into two halves.

Giant Dynamos. At the other end of the scale of development we have the gigantic machines in the power-houses of our electric lighting and traction enterprises. It is quite frequent in tramway power-houses to find several dynamos each capable of yielding 1,000 amperes at an electric pressure of 500 volts, and therefore taking some 750-horse power each to drive them. Generators even up to 2,700 kilowatts, taking over 3,500-horse power each, with 36 poles surrounding an armature 21 ft. across, and a commutator 15 ft. in diameter, are in operation. The armature of one such machine weighs 80 tons, and the entire machine 150 tons. Fig. **76** shows the machine as erected in the power-house at Boston, having been built by the General Electric Co., at Schenectady.

The Dynamo Concluded

Group 26

SHOPKEEPING

9

Continued from page 1186

CYCLOPÆDIA OF SHOPKEEPING

BOOT AND SHOE RETAILERS. Capital and Stock. Buying and Selling. Technical Instruction. Measuring. Fitting Deformed Feet

BUILDERS' MERCHANTS. The Scope and Possibilities of the Business. The Stock. Terms of Credit. Buying, Selling, and Profits

BOOT AND SHOE RETAILERS

Capital. It is impossible to give any specific information applicable in all cases as to the amount of capital required in the retailing of boots and shoes. A town trade requires a more varied stock than a country trade and must be of a different nature. The individual ability of the proprietor, the proximity of the sources of supply, and the ability to secure speedy execution of orders, and other considerations influence the sum required. If the shopkeeper is able to do a good repair trade less capital may suffice, because the retailing of boots and shoes is not the only source of income; but in a general mixed provincial business it may be accepted that a good representative all-round stock cannot be placed on the shelves for less than £500. Should this capital not be at command, the future may be pledged – that is to say, the wholesalers, who are always willing to extend facilities to a really good man starting business, may give terms of credit or accept bills for a large part of the opening order.

Stocking. We may consider how the beginner might lay out the sum of £500 in a good selection of boots and shoes. Our calculation is intended to represent the stock in a good provincial town where there is not a preponderating demand for any one class of footwear. In a city like London many boot shops scarcely cater for the trade in ladies' shoes. Such articles, on the other hand, would occupy chief place on the shelves of a shop in a London suburb. The husband buys his boots in the City, the wife and children purchase theirs at the local boot and shoe store. Also in a mining village, or a fishing port, stock to suit the locality would be different from that we are about to describe. With these reservations regarding the practical value of our scheme of purchasing stock, we may indicate the manner in which the average general boot and shoe retailer in a popular marketing neighbourhood might do well to expend his £500.

Details of Stock and Profits. We may allow the beginner £100 for men's footwear. Of this sum, £20 might be spent on heavy boots for working men. This trade is becoming smaller in most districts. Workmen are beginning to favour lighter boots which do not last so long, and which, therefore, need earlier replacement. Also, this is often a cut trade, especially in the lowest priced classes. A boot bought at 3s. a pair may have to be sold at 3s. 11d. But the average price of heavy boots for working men is higher than this. The bulk of the trade is in boots costing 5s. to 5s. 6d. a pair and retailing at 6s. 6d.

Ordinary cheap walking boots account for the bulk of the trade in the men's department, and £60 may be spent on them. Prices range from 8s. 11d. to 10s. 6d., and the profits range from 27 per cent. to 33 per cent. Box calf and even glacé kids are gaining favour in this class of trade. The proportion of brown boots to black is from 10 to 15 per cent. of the former.

Then the remaining £20 in the £100 may be allotted to what are termed "gent's light wear." These will consist of box calf, glacé kid, and a few patent-leather boots. They yield better rates of profit than the cheaper classes—a 16s. 6d. boot costing, say, 11s. 6d. The sizes of men's boots should range from 5's to 11's with three fittings in each size. Sizes 7 and 8 being the most common sizes should be bought in greater quantity. For the beginner with the capital we set out to spend, half-sizes would not be possible, unless the variety is limited.

Ladies' Boots. Our beginner may disburse £120 upon his opening stock in the ladies' department. We shall allow him £20 for stout leather boots for working women. These will cost from 3s. 9d to 4s. a pair and he will retail them at 4s. 11d a pair. The greater part of the trade in ladies' boots will be in ordinary walking boots sold at 6s. 11d to 8s. 11d, and a good assortment suitable for the trade we are considering cannot be put into stock for less than £70. A profit of 25 per cent. on takings may be looked for all round, but in the cheaper classes a little cutting under this rate may be advisable. This will depend upon the policy pursued by the near competitors of the retailer.

Ladies' "light wear" will absorb the remaining £30 of the sum apportioned to the ladies' department. The stock will retail at from 10s. 6d. to 16s. 6d. a pair, and the profits will be similar to those upon men's boots of similar quality.

Youths' and Boys' Boots. The sum of £100 may properly be spent in youths' and boys' boots. They may be divided into four classes: Youths' working boots, youths' best boots, boys' school boots, and boys' best boots. And to each class may be allotted £25. Youths' sizes range from 2's to 5's. Youths' working boots retail at from 4s. 9d. to 6s. 6d., and youths' best from 5s. 6d. to 8s. 6d. a pair. Prices rise by 3d. per size. The smaller sizes are usually cut in price somewhat, often showing a profit of only 6d. a pair, but this is made up on the larger sizes upon which 2s. 6d. may be had. Public opinion does not recognise that the labour, and therefore the expense, of making a small boot is equal to that in a larger article, and the practice mentioned is a concession to public opinion. If the average of 25 per cent. over the whole be maintained the boot retailer may follow this practice with the knowledge that, although certain individual sales may not show their proper margin, the aggregate profit is satisfactory.

Boys' boots include the sizes from 11's to 1's. Boys' school boots retail at 4s. to 4s. 11d., and boys' best boots at from 5s. to 6s. 6d. The practice and profits mentioned as pertaining to youths' boots apply here also.

Children's Boots. This department will account for an expenditure of £40 in the stock order; £20 for children's school boots and £20 for "best wear" or "Sunday boots," as they are sometimes called. Prices of the former are from 2s. 11d. to 4s. 11d., and of the latter from 3s. 11d. to 6s. 11d. All sizes range from 7's to 1's. .

Slippers and Sundries. The sum of £20 will put in a good stock of slippers, from common house slippers to dancing pumps. A matter of £4 may be spent on infants' and nursery boots which retail at from 1s. to 4s., in sizes from 1's or 2's to 6's. Then comes the department of sundries, which should be encouraged, as being much more remunerative than the more important trade. Sundries include laces of all sorts, leggings, gaiters, and polishes and blackings, which yield very good profits indeed. Indiarubber heels are, at the time of writing, selling very well indeed, and promise to retain their hold upon public taste for some time yet, if not indefinitely. The man intending to build up a good family trade will strive to avoid selling the very cheap varieties. They will not establish a reputation for quality. But a really good rubber heel may be bought at 5s. 3d. per dozen and sold at 9d. a pair, while those costing 7s. 3d. per dozen will be sold at 1s. a pair.

Our estimate of expenditure has not included special boots, such as cycling shoes, golfing, shooting, and football boots, as such things are special, and are not necessary items in every boot shop. The likelihood of selling any or all of them should decide the question of whether or not money should be spent on them.

All Leather or "Compo." Much has been spoken and written regarding the wisdom or otherwise of selling boots which are not of leather throughout. Such boots should not be sold as of all-leather, but provided they are sold for what they are, or if no claims be made for their material, nothing can be said against the trade. And the retailer learns that he can often give the public better value in a mixed boot at a certain price than he can in an all-leather boot at the same price. When an all-leather boot has to be produced at a certain very low price, the leather is of the lowest quality that will bear the name, the workmanship must be crude, the fit uncertain, and the finish poor. In an honestly made mixed boot the leather, on the other hand, may be put into the parts that have to withstand wear, and the money saved by the canvas and composition used in the parts not subject to the same wear may be put into workmanship and finish. The result may be an article not less useful and durable, but certainly more elegant and saleable. Consider a lady's boot at 5s. 6d. a pair. How poor is the appearance, and perhaps the fit, of such an article if all-leather be insisted on! How much better-looking, without necessary inferior qualities, may be a composition boot at the same price!

Buying. The entrant into the boot trade who has the placing of the stock order we have detailed will not be able to purchase from the manufacturers. Such a course would entail the division of the order into about a dozen sections, and most of them would be too small for direct dealing. Therefore, he must content himself by enlisting the good offices of a factor or middleman, although this will cost him a little more. But by making a good factoring house his source of supply, he can usually secure accommodation should he want it, and that may be far more important to him during his early struggles at establishing a business than the saving of the small percentage that direct buying might give. Factors' terms are usually net at one month, unless under special arrangement. Manufacturers' terms differ. Some makers allow 6¼ per cent., and other makers 5 per cent. for prompt cash, which means payment within seven days after invoice date.

Assistance and Selling. Shop assistance in the boot-selling trade is not highly paid. In the cities a lad may be had at from 10s. to 15s. a week, and in the provinces girls are often employed at from 2s. 6d. to 10s. a week. Even in London a good, smart, all-round assistant can be had for 28s. a week, so that assistants' salaries do not account for an undue proportion of the dead charges in the boot retailing business.

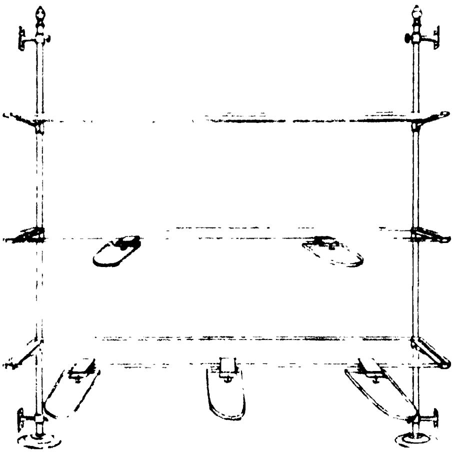
The terms upon which boots are sold depend upon the locality and the nature of the trade. In the cities it is nearly all of a cash description, but in the family trade in the provinces the credit turnover may rise to 50 per cent. of the total. An iniquitous practice has crept into the trade. It is by no means general, but sufficiently common for notice and stricture here. It is not unusual that an assistant may reap benefit by "fleecing the greenhorns." If it be evident that a customer is ignorant of boots and not particular as to price, the assistant may sell a 10s. 6d. boot for, say, 12s. 6d. or 14s. 6d., and thereby pocket a considerable commission, say, half the excess. On moral grounds the practice is to be condemned, but even on the lower grounds of business policy it is questionable if it be really remunerative.

The subject of selling cannot be dismissed without a reference to turnover. The number of times that a boot and shoe retailer can turn over his stock depends, as in every other trade, upon his perspicacity as a close buyer. Twice a year may be taken as the average, but our man with £500 worth of stock would not show very good net profits if he did no more than this.

It would mean that his gross profits were only £250 a year, or thereby, and when rent, wages, and other charges had been paid from this the net balance would be a poor return for his enterprise. But the new venturer buys carefully, ordering often as blanks occur, and in this manner he may turn over his stock, say, three times a year.

Repairing. A repairing department is a desirable and a usual addition to any boot and shoe retailing business. The necessary equipment is not expensive, and any man with limited capital should certainly adopt it as a feature. The sum of £20 will purchase everything necessary—a sewing machine (a Bradbury for preference), an assortment of cut soles and heels, a few pounds of patching leather, iron sole plate and lasts, and the necessary grindery and small tools. The regular prices for soling and heeling are 2s. 6d. up to 4s. for men's work. The lower figure is the common working man's price, and it may yield a good wage to a good workman, but not a large profit to the employer

Occasionally, repairing is undertaken upon a more ambitious scale, with a full equipment of good machinery operating in full view of the public street The machinery in such a case includes a Blake sole sewer, a stitching machine for welted work, and a finishing machine, which may all be installed for £100. A power producer is necessary, and is usually a gas engine, which may, however, be hired or paid for upon the instalment system The plant indicated and three men as operators should overtake, say, thirty "sole and heel" jobs per day, yielding 9d. each gross profit, and giving the proprietor about £200 a year net profit. This compares favourably with the mere selling of boots and shoes in return for money invested, and the good practical man may often find it the preferable venture. The field is, of course, rather limited, as it is only cities and large towns where sufficient constant trade for such a repairing shop can be got.



1. BOOT RETAILER'S WINDOW ARRANGEMENT

Shop and Window Fittings. The stocking of boots and shoes is a comparatively easy matter now that the practice of having each pair in a cardboard box is all but universal. The shelving should be of a size to allow the boxes to stand three to the height. If four be placed in a tier, the shelves are more apt to become untidy, and "three-high" is the most convenient system. The art of window dressing is receiving much greater attention than formerly. It is becoming recognised that taste in arrangement, and not quantity of exposed stock, is the criterion of an attractive and effective boot window Many makers of window fittings offer large selections of display stands speciallv designed for the boot selling trade. The neatest, cleanest, and most convenient window arrangement is that shown in 1. The glass shelves are preferable to those of any other variety, as they may be most easily kept clean. The projecting glass plates which are attached to the front of the shelves serve to throw into desirable prominence single boots, and success in window dressing depends upon the attention drawn to individual articles. The cost of a window arrangement, as illustrated, may be estimated from the following prices of the component parts

Brass cased tube for uprights, 1 in., plain, 6d. per foot.

Brass cased tube for uprights, 1 in., ornamental, 1s. per foot.

Brass end knobs, from 6d. per pair.

Bottom sockets, from 1s. per pair.

Side fixings for standards, 1s. per pair.

Shelf brackets, with sockets for 1-in. tubes and for 10-in. shelves, 2s. each.

10-in. plate glass shelving, polished edges, about 2s. 3d. per foot.

Glass plates, as shown, 7 in. × 3½ in., with clips, at about 1s. 2d each.

Calculation of the size of the window and of the length and number of the various fittings required will give the approximate price of the arrangement for any given window. The boot retailer who intends to fit up a shop ought to secure catalogues from the most up-to-date firms of shop-fitters, and select therefrom the fittings most suited to his trade and to the scope of his premises.

The Personal Equation. Having considered the shop, the stock, and the profits of the boot and shoe business, we may turn to a study of the qualities desirable in the man who is to be in charge, whether proprietor or manager. He should be intimately acquainted with the various manual or mechanical processes by which boots and shoes are made. He should understand fully the merits and qualities of the various kinds of leather and other materials which enter into the production of boots and shoes. He should make himself familiar with the difference between the old method of bark tanning and the new method of chrome tanning. It is imperative that he should know something of the anatomy of the foot and its natural functions.

Technical Education. During recent years there has been awakened a keener interest in the application of scientific principles to the art of boot and shoe manufacture. The "American invasion" a few years ago has doubtless been responsible for this. Thus, greater attention than hitherto is being given to technical instruction in the craft. There are numerous institutions where technical training can be secured. In London, such institutions include the Leather Trades School, at 42, Bethnal Green Road, E., and the Polytechnic Institutions in Regent Street, W., and in Borough, S.E. Provincial centres where boot manufacture is taught include Norwich, Leicester, Northampton, Wolverhampton, Stafford, Bristol, Newcastle-on-Tyne, Leeds, Stone, Glasgow, Dublin, Cork, and Ballymena. Lecture courses are frequently given in Northampton villages and in other places, where instruction is desired and where there are no permanent schools.

The Leather Trades School in Bethnal Green is unique in combination of theory and practice of which the student may avail himself. There the boot and shoe *seller* as well as the boot and shoe *producer* may acquire a knowledge which will prove valuable in his work. During the winter or spring term there is given a course of six lessons in foot measuring, and the testimony of pupils is that attendance at these lessons gives the ability to reduce the misfits to something approaching 0 per cent. in daily business practice. The fee for the course of lessons is five shillings.

Shop Practice. Tact, like civility, plays an important part in any business, and almost every customer requires different treatment. Some are easily satisfied, some only satisfied with difficulty, while some customers are never satisfied. There is probably nothing which irritates a customer more, or which so easily leads to dissatisfaction (and to a dissatisfaction which is unjustifiable) than the common practice of trying on a half-dozen or a dozen kinds of boots before a fit is secured. For this reason every shoe seller should make himself familiar with the size and fitting of every kind and grade of footwear in his establishment, and be able, after taking the measurement of a person's foot, to go to his stock and select the exact size required instantly. Unfortunately, there is not at the present time a recognised national standard of sizes to which all makers conform. Almost every lastmaker has his own particular sizes, whilst the vanity of those with large feet has led to a serious corruption of sizes, many boots and shoes—those intended for ladies especially—being marked a size and fitting smaller than they are. The shopkeeper should insist upon the maker supplying him with his—the maker's—standard, in order that he may know what differences exist between the various makes. The tables given in next column show a scale of sizes used by many makers.

Measuring the Foot. The foot should be measured when at rest—that is to say, no weight should be placed upon it. The points of measure are the joints, the instep, the heel, and the leg. The particular shape of the foot should determine the particular form of shoe best suited to it, but as the wearer requires boots and shoes which, figuratively speaking, have to fit his head as well as his feet, a compromise has invariably to be effected. Should a plan or "draft" of the foot be needed, it can be made by resting the foot on paper, pressing the foot only lightly, and marking it round [2], taking great care to hold the pencil absolutely vertical, and marking on the draft the position where all measurements are to be taken across the foot. In taking the length of the foot, it is customary to allow 2 sizes in the length for boys, 2½ for ladies, and 3 for men—that is to say, if a boy's foot measures 5, the boot or shoe required should measure a 7 in length. In taking the girth measures of a fat, or fleshy, foot, the measuring tape should be drawn moderately tight; but with a bony foot there should be no compression. If the foot be short and thick, and it be desired to give it a smarter appearance when clothed, three sizes instead of two may be added to the length, but the toe should be what is known as "cased," so that the leather at the toe does not fall in beyond the toes and become unsightly. Glove kid or buckskin should be recommended to persons with very tender feet.

SCALE OF JOINT AND INSTEP MEASUREMENTS

GENTLEMEN'S

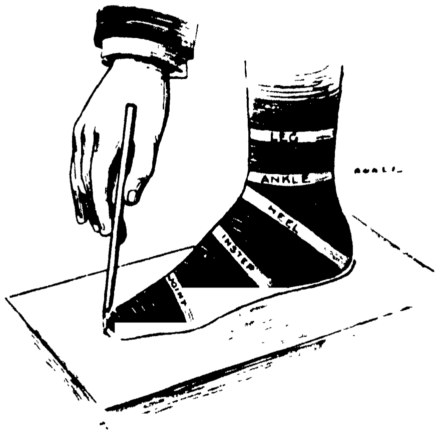
Size	2 Fitting		3 Fitting		4 Fitting		5 Fitting		6 Fitting	
	Joint	Instep	Joint	Instep	Joint	Instep	Joint	Instep	Joint	Instep
11	9½	9⅞	9¾	10⅛	10	10⅜	10¼	10⅝	10½	10⅞
10	9¼	9⅝	9½	9⅞	9¾	10⅛	10	10⅜	10¼	10⅝
9	9	9⅜	9¼	9⅝	9½	9⅞	9¾	10⅛	10	10⅜
8	8¾	9⅛	9	9⅜	9¼	9⅝	9½	9⅞	9¾	10⅛
7	8½	8⅞	8¾	9⅛	9	9⅜	9¼	9⅝	9½	9⅞
6	8¼	8⅝	8½	8⅞	8¾	9⅛	9	9⅜	9¼	9⅝
5	8	8⅜	8¼	8⅝	8½	8⅞	8¾	9⅛	9	9⅜

LADIES'

Size	2 Fitting		3 Fitting		4 Fitting		5 Fitting		6 Fitting	
	Joint	Instep	Joint	Instep	Joint	Instep	Joint	Instep	Joint	Instep
7	8¼	8⅝	8½	8⅞	8¾	9⅛	9	9⅜	9¼	9⅝
6	8	8⅜	8¼	8⅝	8½	8⅞	8¾	9⅛	9	9⅜
5	7¾	8⅛	8	8⅜	8¼	8⅝	8½	8⅞	8¾	9⅛
4	7½	7⅞	7¾	8⅛	8	8⅜	8¼	8⅝	8½	8⅞
3	7¼	7⅝	7½	7⅞	7¾	8⅛	8	8⅜	8¼	8⅝
2	7	7⅜	7¼	7⅝	7½	7⅞	7¾	8⅛	8	8⅜

Fitting Deformed and Awkward Feet. This is a task which should be left to the bespoke bootmaker, but it is frequently undertaken by the ordinary shopkeeper, with questionable success. The latter gets the "specials" or "measures," as they are termed, from the wholesale manufacturer, who, not seeing the actual foot to be fitted, fails sometimes—indeed, more often than not—in fitting the foot. To avoid this, the proper course is to take a plaster cast of the foot, and to send the cast as well as measurements to the maker. This is not a difficult operation, and is accomplished in the following manner.

Taking a Plaster Cast of the Foot. A box consisting of three parts, as shown in the diagram [8], is required. A is the false bottom grooved at the edges so that the frame B will fit snugly. D and E are foot-rests, so placed as to come at the ball and heel of the foot. They should be 1 in. square at the base, $\frac{3}{4}$ in. at the top, and 1 in. in height. Care must be taken to have these rests firmly attached to the bottom A, and any opening there may be in the joint at the base filled with putty, to prevent the plaster from filling. The frame C fits on the frame B, and is held in place by the four bits of wood F, which are screwed or glued to the sides of the frame. The frames B and C are each 3 in. high, and are as smooth as possible inside, as is also the bottom A.



2. MAKING A PLAN OF THE FOOT

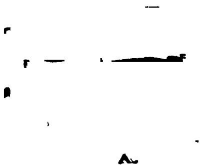
To take the cast, grease the inside of the frame B, also the bottom A; place the frame B in position on the bottom A. Before the foot is placed in the box it, like the box, must be greased. A mixture of tallow and oil is best. Be careful that not one spot be left unoiled, else the plaster will adhere to it, causing no end of trouble. Add the water to the plaster-of-Paris until it has the consistency of paste, not too thin.

Warm water is commonly used as it causes quicker setting than cold water. Place the foot in position [4] in the box at once. The foot-rests D and E are not intended as supports for the foot, but rather as rests, or guides, to steady the foot in its position, and to prevent its movement while the plaster is setting. The foot must not press on them sufficiently hard to interfere with, or rather displace, its contour. The foot should just touch the rests, thus preventing the heel or toes from being "dipped" into the paste before it has hardened.

Making the Mould. Whenever the plaster is mixed to the proper consistency, begin pouring it into the box, until the plaster comes to the rounding of the outer edge of the foot, from the toe to the heel. Allow a few minutes for the plaster to set, then carefully withdraw the foot. It will be found that a perfect imprint of the foot is left in the plaster. In pouring the plaster into the box, see that it comes up to the line of extreme projection all around the foot. Inspection will show that this line is very low down on the outside of the foot, while on the inside it would run from the great toe joint back and upwards parallel with the instep. This can be done by waiting till the plaster begins to thicken, when it can be laid up higher where wanted, and scraped down where not wanted, by use of a blunt knife. In removing the foot, first lift the toes, then draw the foot from the plaster, by moving it obliquely to the front, so as not to disturb the outline at the heels.

After the cast has sufficiently hardened, continue the operation by placing the frame C in position. Grease the foot, and such portion of the cast as has been made so far. Place the foot in position again, and cover the front half of it with a paste mixed a little thicker than at the first operation, finishing it off while in a plastic condition in a vertical line at the ankles. When this has hardened, fill the rear part of the box with the paste, but before doing so, do not forget to oil thoroughly every portion exposed to the plaster, and also the plaster already in the box, else, when the foot is removed, it will be found to be adorned by a plaster ring or anklet, which has to be broken before it can be removed.

The mould is now in three pieces, and after due time has been allowed for them to harden, is ready for the last operation. First remove the front and rear sections of the mould, and thoroughly grease the inner part of all three sections. Next, carefully replace the sections, and the mould is ready for filling. For this operation, prepare your paste of the same consistency as in the first instance, and pour it into the mould. In a short time the frame C can be lifted off, the front and rear sections of the mould removed, and you have exposed a perfect counterpart of the foot, from which a last can be made that will ensure a perfect fit, if the shoemaker does his duty in other respects and sends the correct tape measurement.



8. BOX FOR PLASTER CAST OF THE FOOT

4. THE FOOT IN POSITION

Another method of taking the shape of the foot is with gutta percha, but it is not so reliable.

Trade Literature. The best reference books for the boot retailing trade include the following: "The Manufacture of Boots and Shoes," by F. Y. Golding (Chapman & Hall. 7s. 6d.); "Boot Making and Mending" (Cassell & Co. 1s.); and several books published by the Burlington Co.: "Manual of Boot and Shoe Manufacture," by Hill & Yeoman (4s. 6d.); "Pattern Cutting Made Easy," by T. Brophy (4s. 6d.); "Measurement of Human Foot and Last Fitting," by W. J. Lewis (8d.); "Last Making and Last Measurements," by A. E. Tebbutt (1s. 6d.); and "Pattern Cutting," by W. Morris (1s. 6d.). The trade is also well provided with trade journals.

BUILDERS' MERCHANTS

The business of a builders' merchant lies half-way between what is known as black ironmongery and that of a timber, brick, and slate merchant. In starting as a builders' merchant, the tradesman needs to be quite sure about several matters. His area must be one where land for building operations is being developed, and he should be careful not to plant his depôt too far from a railway-station. Obviously, the ideal spot is adjacent to the goods-yard of a railway company's premises, so that the question of a private siding when the business has developed large proportions will not become a serious one. The importance of considering this point should not be overlooked, especially in provincial towns, where land is not rented at prohibitive prices. When once a business has been established on a reasonably firm basis, the question of adding a saw mill will be sure to crop up, and then the difference between proximity to, and distance from a station may make or mar the opportunity.

Premises. The premises demanded by the requirements of the business must be roomy rather than showy. A good deal of the stock can be kept in the open air without fear of deterioration, but a warehouse will be required for the safe storing of cement, which may well be kept in the ground floor of, say, a three-storey building. The first floor may be devoted to heavy goods, and to such as require to be displayed to advantage—to stoves, ranges, and mantelpieces, for example, if these are included in the stock. A third (the second) floor may accommodate "bread-and-cheese" stock, such as laths, felt, nails, hair, etc. Obviously, a small crane, fixed on the second floor, to serve both, and to facilitate loading and unloading in the yard, will prove serviceable.

Fixtures. Both in the warehouse and in the yard some outlay is necessary to provide suitable fixtures; but these need not be expensive, and, for the most part, open framework answers every reasonable requirement. Racks, standing out from the wall about 24 or 27 in., are suitable for such stock as laths in bundles, wallpaper, and glass—unless the last-named be kept stocked in original crates. These racks, if built on frames out of 3 by 2 in. deal, from floor to ceiling, may be filled in with shelves, made up of the 3 in. stuff ripped twice the 2 in. way, and laid with two, or even two and a half inch space between them. The builders' merchant will be sure to stock corrugated iron, which can best be kept flat in racks, built up of wood uprights, with ¾ in. horizontal tubes, upon which the sheets are laid. The rack should be arranged so that the sheets can be introduced at, and withdrawn from, one end. The clearance between the end uprights will need to be not less than 28 in., which, however, it need not exceed. Each gauge length ought to have its special compartment.

Many builders' merchants stock gutter and spouting, and a few include cast-iron soil pipes in their stock. These can be kept best on end, on racks raised from the floor sufficiently high to allow the pipes to clear the ceiling. Whatever the room then left at the bottom can be utilised for small fittings, such as bends, outlets, stop ends, etc. Nails may even be stocked thus, but a better way is to keep these in their original bags, stocked one above the other between rails fixed at convenient distances apart between the floor and ceiling. As to the small wares, much of the information which will be found in the section devoted to IRONMONGERY applies in the case of builders' merchandise.

Capital. Considerable capital is required to start in a way likely to be followed by success. Less than £600 will barely suffice, while £1,000 is by no means an extravagant estimate. Even then all the capital ought not to be locked up in stock. The selling side of the business is one in which credit must be practised, and some balance at the bank will be almost a necessity. It is useless to ignore the fact that the risks in this business are considerable. The average speculative builder is notoriously a bad payer, and usually hard-up. The conditions under which he conducts his operations compel him to buy cheap materials in the cheapest market, and common builders' goods do not carry a large profit. Against the small profits must be set the fact that the stock, if properly bought, ought to be turned over at least three times, and by enterprising management, four times a year.

Profits and Expenses. It is not possible even to estimate the profits of the various departments. Much depends upon the local conditions. Where conditions are not abnormal, and the competition and price-cutting not very severe—and few trades suffer more than this in that respect—an average of 20 per cent. on the net cost of the goods to the merchant may be looked for; little enough when the heavy expenses are taken into consideration.

These expenses are connected with the sale and distribution of the articles stocked. Business does not come to the yard of a builders' merchant by a process of natural gravitation. It has to be sought, and often keenly contested. In the case of even the smallest concern one man on the road all the time will be absolutely necessary. His salary will be from £70 to £100 a year, with a commission on goods sold and *paid for*. This commission might be not less than 2½ per cent. over all, with extras on special lines. Added to this there will be his travelling expenses which may take the form of railway fares or the upkeep of a horse and trap. Another important source of expense is the carting.

Staff. The wage-bill of the yard and office staff will not be serious, provided the business is under the direct supervision of the principal, who, however, may wisely elect to be his own traveller. In that case a responsible man with a knowledge of the details of the business will be wanted inside. For the rest, a second salesman, a junior clerk, and one or two strong porters will furnish all the assistance required in even a good-sized concern.

At least one man about the business must be a capable man of affairs. It may be the proprietor if he does not travel, or the chief clerk, but owing to the conditions under which the work has to be carried on, a specially sharp eye must be kept on the financial side.

Stock. We have already pointed out that the stock of a builders' merchant lies within the confines of two other distinct trades. It is an essential condition that the stock should be bought at rock-bottom prices, on the best possible terms, and from the actual manufacturers or producers. The man who expects to succeed must set himself steadfastly against buying from the merchant bigger than himself.

Practically the stock falls into three or four classes, of which some indication may be given.

Class A may comprise the stock which can be termed *glazed earthenware*. Some of it will be salt glazed, and include drain-pipes, invert blocks, gulley and intercepting traps, access pipes, bends, etc. Of better quality there will be cane, or cane-in and white-out sinks for the kitchen, scullery, and pantry, water-closets, S. and P. traps, etc., while highest of all will be stocks of white, marbled, and printed closet pans, lavatory basins, some of which, especially in the fireclay qualities, run to considerable prices.

Class B will be that nearest to ironmongery, and will comprise ironfoundry and metals. Stocks of portable and cottage cooking ranges command a ready sale, and some attention will have to be paid to better-quality kitcheners for residential property, as well as to register grates, stoves, and mantelpieces. These last will include cast iron, which is now very much in vogue, enamelled slate, less favoured than formerly, and, if the business be a good-class one, in white painted canarywood and in fumed oak, polished walnut and mahogany. Sheets for roofing and gutter and spouting we have already mentioned. Furnace pans will be called for, and nowadays copper and galvanised iron have to be supplemented by iron rendered rustless by the Bower-Barff process, which is an oxidation produced artificially to prevent the natural rusting which might occur in use.

On the sanitary side stocks of soil pipes, lead pipes, manhole covers, water waste preventers, and baths must be considered. Besides, there will, or may be, lead in rolls for roofing, cisterns and tanks, plumbers' taps and fittings, possibly gas-tubes and fittings, "compo" pipe, door furniture, locks, hinges, sheet zinc, hoop iron for floor board tongues, fencing and gates, and, if the district is a good one, stable fittings.

Class C. Part of the "ware" in Class A will naturally find a place in the open yard or under covered sheds, where also will be roofing tiles, timber if it be kept, slates, chimneytops, paving stones, blue and red paving tiles, wall copings, roof ridge tiles, stable and forecourt bricks with chequered surfaces.

Class D will be stored in the warehouse. Two or three brands of felt for damp course work and roofing will be kept, plasterers' hair, paint, glass, putty, scaffold ties—there are several excellent metal ones on the market—ropes, plasterers' laths, etc.

Finally, there must be mentioned cement, one of the most important items in the whole stock. The technical side of this matter ought to be studied thoroughly, and much sound information will be found under the section devoted to BUILDING. Ordinarily, the stock will comprise Portland cement, chiefly used for external work, Parian cement for inside walls, and Keene's cement for mouldings, cornices, arrises, and other positions where a hard, smooth surface is essential. The mention of walls reminds us that metal lathing is now largely used, and patent partitions in great variety are not infrequently used, in place of stud work and lath and plaster. Here, again, the up-to-date builders' merchant often finds his opportunities. The fact is, there is no limit to the possibilities of the business, and what is true of many others is true of this—namely, that the best plums are at the top of the tree. The stock that carries the best profits is that required for the best quality of work.

Hiring Out Appliances. When the business has been fairly established, there may occur opportunities for hiring out apparatus and plant, and £100 invested in this direction ought to show a good profit. In most districts there is a demand from builders and others for such plant as drain-cleansing tools, and testing machines, hoisting-crabs or winches, contractors' pumps, pulley-blocks and lifting tackle, bottle-jacks, and even for such large machines as cranes, mortar-mills, and rotating screens. A reputation for holding all these in good repair ready for immediate use will ensure inquiries, and as most of the articles enumerated are strongly made, the risks of loss from damage are not great.

Finally, the office of a builders' merchant cannot be considered properly equipped unless it contains a library of catalogues and technical literature. In no trade are more yearly price books published. These ought to find a place on the shelves as should also the catalogues of ironfounders, quarry and pottery owners, manufacturers of terra-cotta, besides those of manufacturing brassfounders, lock makers, woodworkers, etc. Practically, it is not possible to stock all that a district will require, and therefore it is important to have close at hand particulars of specialities occasionally called for by customers.

Continued

LATIN—ENGLISH—FRENCH—GERMAN

Latin and English by G. K. Hibbert, M.A.; French by Louis A. Barbé, B.A.; German by P. G. Konody and Dr. Osten

Group 18
LANGUAGES
9

Continued from page 1191

LATIN

Continued from page 1184

By Gerald K. Hibbert, M.A.

SECTION I. GRAMMAR

Irregular Verbs: Third Conjugation

The following are the most important:

A. CONSONANT VERBS

Guttural Stems, *-si*, *-tum* (five, *-sum*)

dico	dixi	dictum	*say*
duco	duxi	ductum	*lead*
cingo	cinxi	cinctum	*surround*
coquo	coxi	coctum	*cook*
fingo	finxi	fictum	*fashion*
pingo	pinxi	pictum	*paint*
jungo	junxi	junctum	*join*
tego	texi	tectum	*cover*
-stinguo	stinxi	stinctum	*quench*
tinguo	tinxi	tinctum	*dye*
unguo	unxi	unctum	*anoint*
traho	traxi	tractum	*draw*
veho	vexi	vectum	*carry*
vivo	vixi	victum	*live*
struo	struxi	structum	*pile*
-lacio	lexi	lectum	*entice*
-specio	spexi	spectum	*espy*
fluo	fluxi	fluxum	*flow*
figo	fixi	fixum	*fix*
mergo	mersi	mersum	*drown*
spargo	sparsi	sparsum	*sprinkle*
tergo	tersi	tersum	*wipe*

Dental Stems, *-si*, *-sum*.

claudo	clausi	clausum	*shut*

Similarly, divido, lædo, ludo, plaudo, rado, rodo, trudo, and vado. Also:

cedo	cessi	cessum	*yield*
mitto	misi	missum	*send*
quatio	(quassi)	quassum	*shake*
flecto	flexi	flexum	*bend*
necto	nexi	nexum	*bind*

Labial Stems, *-si*, *-tum*.

carpo	carpsi	carptum	*pluck*

Also repo, scalpo, serpo, nubo (nupsi), and scribo (scripsi).

Liquid Stems, *-si*, *-tum* (one, *-sum*).

como	compsi	comptum	*adorn*

Also demo, promo, sumo, temno, premo (pressi, pressum), gero (gessi, gestum), uro (ussi, ustum).

Stem various, *-ui*, *-tum* (one, *-sum*).

cumbo	cubui	cubitum	*lie down*
elicio	elicui	elicitum	*entice forth*

Also strepo, fremo, gemo, tremo, and vomo.

rapio	rapui	raptum	*seize*
alo	alui	altum	*nourish*

Also colo (colui, cultum), consulo, occulo, pono (posui, positum), gigno (genui, genitum), texo (texui, textum), sero = I join (serui, sertum), and meto (messui, messum).

Present Stem Anomalous, *-vi*, *-tum*.

lino	levi	litum	*smear*
sino	sivi	situm	*allow*
cerno	crevi	cretum	*sift, discern*
cresco	crevi	cretum	*increase* (intrans.)
sperno	sprevi	spretum	*despise*
sterno	stravi	stratum	*strew*
sero	sevi	satum	*sow*
nosco	novi	notum	*know*
pasco	pavi	pastum	*feed*
suesco	suevi	suetum	*be accustomed*
quiesco	quievi	—	*rest*
cupio	cupivi	cupitum	*desire*
peto	petivi	petitum	*ask*
quæro	quæsivi	quæsitum	*seek*
tero	trivi	tritum	*rub*
arcesso	arcessivi	arcessitum	*send for*
lacesso	lacessivi	lacessitum	*provoke*

-i, *-sum* (one, *-tum*).

pando	pandi	pansum (passum)	*spread*

Also scando, prehendo, -cando, -fendo, verto (verti, versum), bibo (bibi, bibitum), vello (velli or vulsi, vulsum).

findo	fidi	fissum	*cleave*
scindo	scidi	scissum	*tear*

Roman Money

Most of the Roman weights and measures were divided by fractions which were originally parts of the *As* or pound weight, containing twelve ounces. The *As* was thus divided:

Unciæ, *i.e.*, Ounces.		Fractions of As.
12	As, *a pound*	1
11	Deunx (de-uncia), *an ounce off*	$\frac{11}{12}$
10	Dextans (desextans), *a sixth off*	$\frac{5}{6}$
9	Dodrans (dequadrans), *a fourth off*	$\frac{3}{4}$
8	Bes, or Bessis (dui-assis)	$\frac{2}{3}$
7	Septunx (septem unciæ), *seven ounces*	$\frac{7}{12}$
6	Semissis, or Semis (semi-assis)	$\frac{1}{2}$
5	Quincunx (quinque unciæ)	$\frac{5}{12}$
4	Triens, *a third*	$\frac{1}{3}$
3	Quadrans, *a fourth*	$\frac{1}{4}$
2	Sextans, *a sixth*	$\frac{1}{6}$
1	Uncia, *an ounce*	$\frac{1}{12}$

Other fractions used were *Sescuncia* (1$\frac{1}{2}$

ounces), *Semuncia* (½ ounce), *Sicilicus* (¼ ounce), *Sextula* (⅙ ounce), *Scripulum* ($\frac{1}{24}$ ounce).

Interest on Money. After B.C. 80 legal interest was fixed at the rate of $\frac{1}{100}$ of the Capital *per month*, called Centesima (sc. *pars*)—*i.e.*, 12 per cent. *per annum*. Lower rates than this were denoted by the fractional parts of the *As* (the Centesima being taken as the As). Thus, reckoning the percentage as per annum :

12 per cent. = *usuræ centesimæ*, or *asses usuræ*.
11 per cent. = *usuræ deunces*
8 per cent. = *usuræ besses*
5 per cent. = *usuræ quincunces*
1 per cent. = *usuræ unciæ*

Higher rates than 12 per cent. were denoted by distributives :

24 per cent. = *binæ centesimæ*
60 per cent. = *quinæ centesimæ*

Expression of Fractions. 1. All fractions with 1 for numerator are denoted by ordinals, with or without *pars* : ⅓ = *tertia*, or *tertia pars* ; ¼ = *quarta*.

2. All fractions with a numerator less by one than the denominator are denoted by cardinals with *partes* simply : ⅔ = *duæ partes* ; ⅚ = *quinque partes*.

3. All fractions with 12, or its multiples, for a denominator, are denoted by the parts of an As, which is taken as the whole :

Heres ex asse = heir to the whole estate.
Heres ex triente = heir to a third
Heres ex semisse = heir to a half.

4. All other fractions are denoted by the cardinal for a numerator, and the ordinal for the denominator : $\frac{4}{7}$ = *quattuor septimæ*.

Expression of Sums of Money. Although the *denarius* (= 10 asses) was the silver coin in most frequent currency, the ordinary unit of reckoning was the *sestertius*, or *nummus* (= ¼ denarius, or 2½ asses). The Roman sign for 2½ was IIS—*i.e.*, II. + S(emis). This is now written HS, and is the usual abbreviation for a sestertius. Thus, 7,000 sesterces = *septem millia sestertium* (shortened from *sestertiorum*).

This shortened form *sestertium* was taken for a neuter singular noun, meaning 1,000 sesterces, and so we get such forms as

Sestertia decem = 10,000 sesterces.

For sums of a million sesterces and upwards, adverbial numerals are used—*e.g.*, 1,000,000 sesterces = *decies centena millia sestertium* (or, more usually, just *decies sestertium*).

2,300,000 sesterces = *ter et vicies sestertium*.

To distinguish the meanings, strokes were usually added to the numerals—*e.g.*, $\mathrm{HS}\overline{\mathrm{X}}$ = *decem millia sestertium* (10,000) ; $\mathrm{HS}\,\overline{|\mathrm{X}|}$ = *decies sestertium* (1,000,000).

SECTION II. SYNTAX.

Sequence of Tenses. 1. If the verb in the principal clause is in a *primary* tense (*i.e.*, present, future, or true perfect), the verb in the subordinate clause will be (*a*) in the present subjunctive if present time be denoted ; (*b*) in the perfect subjunctive if past time be denoted—*e.g.* :

Rogavi ut illi ignoscatur = I have asked that he may be pardoned.

Cognoscam cur venerit = I will ascertain why he came.

2. But if the verb in the principal clause is in a *historic* tense (*i.e.*, imperfect, simple past, or pluperfect), the verb in the subordinate clause will be (*a*) in the imperfect subj. if present time be denoted ; (*b*) in the pluperfect subj. if past time be denoted—*e.g.*,

Rogavi utrum adesset = I asked whether he were present.

Non dubium erat quin fugisset = there was no doubt that he had fled.

Infinitive Mood. The infinitive is an indeclinable verbal noun. It is used as object, as predicate and as subject, so far as a substantive in the acc. or nom. case would be so used. It is not properly used as a genitive, dative, or ablative, or as an acc. after a preposition. The gerund (also a verbal noun) is used instead.

1. As subject : *Dulce et decorum est pro patria mori* = dying for country is sweet and comely.

2. As object : *Vincere scis* : *victoria uti nescis* = you know how to conquer, but not how to use your victory.

3. As predicate to a subject in the nom case ; to express the occurrence of actions without marking the order of time. Often used in narration for a finite verb, hence called historic infinitive—*e.g.*,

Clamare omnes = all cried out.

Rex primo nihil metuere, nihil suspicari = the king at first feared nothing, suspected nothing.

Gerunds and Supines. 1. These are the cases of the infinitive. As mentioned above, the *gerund* is used to express the gen., dat., abl., or acc. after a preposition, of the verbal noun—*e.g.*, *Breve tempus satis longum est ad bene honesteque vivendum* = for living well and honourably, a short time is long enough. *Fugiendo vincimus* = we conquer by fleeing. *Videndi et audiendi delectatio* = the delight of seeing and hearing.

2. The supine in *-um* is an acc. after verbs of motion. It often has a direct, more rarely an indirect, object—*e.g.*, *ibo lusum* = I will go to play.

Deos atque amicos it salutatum ad forum = he goes to hail the gods and his friends at the forum.

Non ego Graiis servitum matribus ibo = I will not go to serve Grecian matrons.

NOTE. This supine, with *iri* (pass. infin. of *eo*), forms the fut. infin. pass.—*e.g.*, *rectum iri*.

3. The supine in *-u* is used in the abl. to qualify adjectives in a way which may be classed under the head of "part concerned" (abl. of respect)—*e.g.*,

Formæ terribiles visu = forms terrible to see.

Mirabile dictu = wonderful to say.

The Gerundive. 1. The gerundive is confined to transitive verbs. It is usually substituted for the gerund when the gerund has an object expressed; the object is then attracted into the case of the gerundive, which is made to agree with it in number and gender. *This is very important—e.g., Cæsar comitiali morbo bis inter res agendas correptus est* = Cæsar was twice seized with epilepsy in the midst of transacting business.

Often used (like the supine in *-um*, or the fut. ptc.) to express purpose, instead of *ut* with the subj.:

Missus est a senatu ad animos regum perspiciendos (translate "for the purpose of discovering").

Hi septemviri fuerunt agris dividendis ("for dividing lands").

NOTE. The gerundive is used from *utor, fruor, fungor, potior*, all these verbs being originally transitive.

2. The impersonal gerundive implies necessity, principally in intransitive verbs. This is the usual construction for expressing "must," and the agent is usually put in the dat., not in the abl. with *a* or *ab*:

Bibendum est mihi = I must drink (literally, it is to be drunk by me).

Suo cuique judicio utendum est = each must use his own judgment.

3. The gerundive is often used as a mere attribute or adjective, meaning obligation, destiny, desert, or possibility.

Deus et diligendus est nobis et timendus = God is both to be loved and feared by us.

Eis otium divitiæque, optanda alias, oneri miseriæque fuere = to them leisure and riches, things desirable in other circumstances, were (for) a burden and a misery.

TO BE TURNED INTO LATIN PROSE.

HOW TO PROCURE CONTENTEDNESS.

BY JEREMY TAYLOR.

If then thou fallest from thy employment in public, take sanctuary in an honest retirement, being indifferent to thy gain abroad or thy safety at home. If thou art out of favour with thy prince, secure the favour of the King of kings, and then there is no harm come to thee. And when Zeno Citiensis lost all his goods in a storm, he retired to the studies of philosophy, to his short cloak and a severe life, and gave thanks to fortune for his prosperous mischance. When the north wind blows hard and it rains sadly, none but fools sit down in it and cry: wise people defend themselves against it with a warm garment or a good fire and a dry roof. When a storm of a sad mischance beats upon our spirits, turn it into some advantage by observing where it can serve another end, either of religion or prudence, or more safety or less envy: it will turn into something that is good, if we list to make it so.

LATIN VERSION OF THE FOREGOING.

Honore amisso in honestum otium quasi in templum defugito, neve pluris lucrum foris quam domi securitatem facito. Et studio regio verso, modo tibi faveat Deus, nihil tibi damno fuerit. Zeno enim Citiensis re inter procellam amissa ad sapientiæ studium togamque brevem et duriorem victum ubi recesserat, fortunæ gratias egit quod sibi ita opportune nocuisset. Et aquilone acri, tristi imbre, soli stulti sedentes flent, sapientis est se toga, igne, tecto defendere. Et ubi malæ fortunæ tempestas in nos inciderit, decet hoc ipsum in lucrum vertere, spectato an ad aliud quid prosit, sive ad fortiores sive ad sapientiores reddendos, sive ad securitatem dandam, sive ad invidiam arcendam. Omnia enim in melius verti potuerint, modo ipsi hoc velimus.

SECTION III. TRANSLATION.

Horace warns Lyce that he cannot put up with her unkindness for ever.

Extremum Tanain si biberes, Lyce,
Sævo nupta viro, me tamen asperas
Porrectum ante fores objicere incolis
    Plorares Aquilonibus.
Audis quo strepitu janua, quo nemus
Inter pulchra satum tecta remugiat
Ventis, et positas ut glaciet nives
    Puro numine Jupiter?
Ingratam Veneri pone superbiam,
Ne currente retro funis eat rota.
Non te Penelopen difficilem procis
    Tyrrhenus genuit parens.
O, quamvis neque te munera nec preces
Nec tinctus viola pallor amantium
Nec vir Pieria pellice saucius
    Curvat, supplicibus tuis
Parcas, nec rigida mollior æsculo
Nec Mauris animum mitior anguibus.
Non hoc semper erit liminis aut aquæ
    Cælestis patiens latus.

ENGLISH VERSION OF ABOVE.

Even though you drank of the far-distant Tanais, Lyce, wedded to a savage husband, still you would grieve to expose me, stretched before your cruel doors, to the north winds of the land. Do you hear how loudly the door, how loudly the grove planted within your fair abode groans beneath the blast, and how Jove, with his clear influence, freezes the fallen snows? Lay aside the pride displeasing to Venus, lest rope and wheel run back together. 'Twas not to be a Penelope unyielding to suitors that your Tuscan father begot you. O, although neither gifts nor prayers nor lovers' paleness with its violet hue, nor husband smitten with love for a Pierian mistress, can bend you, yet spare your suppliants, though not more pliant than the unbending oak nor gentler in heart than Moorish serpents. Not for ever will this body of mine endure your threshold or the rain of Heaven.

Continued

ENGLISH

Continued from page [illegible]

By Gerald K. Hibbert, M.A.

PREPOSITIONS

A preposition is a word which shows how things, or their actions or attributes, are related to other things—*e.g.*, "The man *in* the moon" (*in* showing the relation of the thing *man* to the thing *moon*); "Coming *through* the rye" (*through* showing the relation of the action *coming* to the thing *rye*); "London is full *of* people" (*of* showing the relation of the attribute *full* to the thing *people*). The noun or pronoun following a preposition (and no other part of speech can follow a preposition) is in the objective case, "governed by" the preposition.

Prepositions were originally prefixed adverbially to verbs; they were, in fact, adverbs of place. Thus, "He took the ring *off* his finger," used to be "he *off*-took the ring his finger," *ring* being direct object, and *finger* indirect. Gradually they were detached from the verb, and became prefixed to the noun or pronoun constituting the indirect object, losing in the process the force of adverbs and becoming prepositions. We have still some of these compound verbs remaining, as *overreach*, *undertake*, *upbring*, *withstand* (stand against), *withdraw* (draw from), *gainsay* (say against).

Classification of Prepositions. Prepositions may be classified as *Simple* and *Compound*. The simple prepositions are *at*, *by*, *for*, *from*, *in*, *of*, or *off*, *on*, *through*, *till*, *to*, *up*, *with*.

The most important compound prepositions are:

aboard
about
above
across
against
along
amid(-st)
among(-st)
anent (= concerning)
(a)round
aslant
astride
athwart
before
behind
below

beneath
beside(-s)
between
betwixt
beyond
but (by-out)
down, adown
except
inside
outside
since
toward(s)
underneath
after, over, under } formed by the comparative suffix *-er*.

Nearly all in this list are compounded of a preposition and an adverb, or a preposition and a substantive. The initial *a* in these compounds represents *on*, and *be* represents *by*. Thus, *beside* = by side, *aboard* = on board. In *into*, *unto*, *until*, *upon*, *within*, *without*, *throughout*, we have an adverbial particle prefixed to a simple preposition.

NOTES. 1. *Beside* is used of *place*, to denote either nearness to, or remoteness from: thus, "Blessed are ye that sow *beside* all waters" (meaning *by the side of*); "Whether we be *beside* ourselves, it is to God" (meaning *out of ourselves, out of our minds*). When, however, the sense of *over and above* is intended, *besides* is generally used, as "*Besides* Latin, he is also learning Greek."

2. *But* is a preposition when it means *except*. It should then be followed by the objective case, as "No-one was saved but *me*." Consequently, in

"The boy stood on the burning deck
Whence all but *he* had fled,"

there is a grammatical error.

3. *Adown* is literally "off the hill," *dune* or *dun* meaning *hill*.

4. Two prepositions, now obsolete, are found in Shakespeare, Milton, and other early writers—*sans* and *maugre*. *Sans* is the French preposition, meaning *without*—*e.g.*, "a confidence *sans* bound" (*Tempest*). *Maugre* is the French *malgré*, in spite of—*e.g.*, "*Maugre* the Roman" (*Paradise Regained*).

Certain participles, such as *considering*, *concerning*, *respecting*, *pending*, *during*, *notwithstanding*, *saving*, *save*, are often used as prepositions, though they are not really such. Thus, in "*Notwithstanding* your cruelty, I forgive you," the true construction is, "Your cruelty *notwithstanding*, I forgive you," the first three words being in the nominative absolute, and *notwithstanding* filling its proper part as a participle. Similarly, in "*Considering* all things" ("all things considered"), "*Pending* his arrival, I felt much excited" ("his arrival pending"), and so on.

Many prepositions are also adverbs, but it is easy to distinguish the two uses. If the word in question governs a noun or some substitute for a noun, it is a preposition; if not, it is probably an adverb. We say "probably," because it might be a conjunction, or even occasionally some other part of speech.

Examples: "He walked *along* the river" (preposition). "He walked *along* very fast" (adverb). "*Since* his death, I have lived here" (preposition); "He died long *since*" (adverb); "*Since* he is dead, we must not speak evil of him" (conjunction).

In "But me no buts," *but* is used first as a verb, secondly as a noun.

When *to* is used as an adverb, it is usually spelt *too* ("Thou wast a spirit *too* delicate To act her earthy and abhorr'd commands").

Place of the Preposition. A preposition should, if possible, immediately precede the word which it governs. Even in relative and interrogative sentences this order should be observed. It is better and more dignified to say "Of whom are you speaking?" than "Whom are you speaking of?" When, however, in a relative sentence, the relative pronoun is omitted, the preposition is usually placed at the end of the sentence—as: "He is not a man I am fond of" (*i.e.*, "of whom I am fond").

CONJUNCTIONS

Conjunctions are words which join sentences together—as: "I will wait *till* you come." Here *till* joins together the two sentences "I will wait" and "you come." Not every word, however, that connects two sentences, is a conjunction, for we have seen that relative pronouns (*who*, *which*, etc.) and relative adverbs (*when*, *where*, etc.) often connect one sentence with another. With these two exceptions, all words which join sentences together are conjunctions.

The conjunction *and* is peculiar, because, in addition to joining two sentences, it can also join two words, provided they are both of the same kind and stand in the same relation to some other word in the sentence—*e.g.*, "two *and* two are four," "egg *and* milk is a good mixture." But in a sentence like "My parents and my cousins are here," *and* joins two *sentences* ("My parents are here" and "My cousins are here"), not two *words*. *And* is the only conjunction that can join words, though it is sometimes said that *but*, *or*, and *nor* join words. We shall find, however, that in every case these conjunctions really join sentences—*e.g.*, "Neither this nor that is right" stands for "This is not right, that is not right." Such sentences are contracted Compound Sentences.

Classification of Conjunctions. Conjunctions are divided into *Co-ordinative* and *Subordinative*.

Co-ordinative Conjunctions join co-ordinate sentences, that is, sentences of the same rank (Latin *ordo* = rank), neither of which is dependent on the other. The co-ordinative conjunctions are *and*, *both*, *but*, *either*, *or*, *neither*, *nor* (and, according to some grammarians, *because*, *for*, *as*, and *whether*).

Either is the distributive pronoun, and *whether* the relative pronoun, used as conjunctions [See Pronouns]—*e.g.*, "*Either* of the two suits me" (pronoun); "*Either* you or I shall perish" (conjunction).

Or is a shortened form of *either*. *Neither* and *nor* are for *ne-either* and *ne-or*.

But was originally a preposition, meaning *without*, *except*. In phrases like "I cannot but think," "There is no-one but knows," it is a conjunction; also in all cases where it joins two sentences, as "Strike, but hear me," "He loved not fatherland, but himself."

Subordinative Conjunctions join subordinate clauses to a main clause, that is, they unite sentences one of which is dependent on the other—*e.g.*, "He'll be hanged yet, *though* every drop of water swear against it." Here, the second clause depends on the first, or is subordinate to it, therefore the conjunction uniting them is subordinative. Such a sentence as the above is called a *complex* sentence, as opposed to a compound sentence, which consists of two or more co-ordinate clauses united by a co-ordinative conjunction. In a complex sentence, one clause is called the principal clause, and all the other clauses are called subordinate. These subordinate clauses play the part of adverbs, adjectives, or substantives, and are called accordingly, *Adverbial*, *Adjectival*, or *Substantival Clauses* [see next lesson].

The most important subordinative conjunctions are:

1. *That*, introducing substantival clauses—*e.g.*, "He said that he was cold."
2. *If*, *unless*, *except*, etc. (conditional).
3. *Though*, *although*, *albeit* (concessive).
4. *That*, meaning "so that" (consecutive)—as: "It was so cold that the water froze."
5. *That*, meaning "in order that," *lest* (final)—as: "He went out that he might get warm."
6. *After*, *before*, *till*, *until*, *ere*, *since*, *now*, *while*, *as* (temporal).
7. *Because*, *since*, *for*, *as* (causal).
8. *Than* (comparative).

Notes. The conjunction *that* is really the demonstrative pronoun. "He said that he was cold" was originally "He was cold: he said *that*," two co-ordinate sentences. Now one has become subordinate to the other.

Because = "by the cause that," and *albeit* is shortened from "all be it."

Than is now regarded as a conjunction, though it is strictly a relative adverb, meaning *when*, *at which time*. Therefore "The sun is larger than the moon" means "When the moon is large, the sun is larger." Both *than* and *then* are derived from *that*. The noun or pronoun following *than* may be in the nominative case or in the objective, according to the predicate to be supplied, thus: "He hates me more *than* you" may mean "He hates me more than he hates you" (*you* being objective), or "He hates me more than you hate me" (*you* being nominative) Such a sentence as "No one knows better than *me* what I have lost" is, of course incorrect: it should be "than I [know]."

As was pointed out in dealing with relative pronouns, a relative pronoun following *than* is always put in the objective case, even when it is strictly nominative—as: "Cæsar is dead, than *whom* no greater Roman ever lived." *Whom* ought to be in the nominative, as the sentence stands for "Cæsar is dead, and no greater Roman ever lived than *he*."

It will be noticed that many of the subordinative conjunctions take a verb in the subjunctive mood, but as was pointed out in dealing with the subjunctive, the conjunction is no part of the mood.

INTERJECTIONS

These are words interjected or "thrown in" to express some emotion. They do not stand in any grammatical relation to other words, and are independent of the construction of the sentence.

Examples: *Hurrah! Alas! Oh! Ah! Pshaw! Marry!* (*i.e.*, by St. Mary), *Od'sbodikins* (God's body), *Zounds!* (God's wounds).

PUNCTUATION

Punctuation is the right method of inserting stops (Latin *puncta*, points). Stops are written marks to represent oral pauses. If we speak to anyone for a few minutes, and notice carefully the manner of our speech, we shall find that we make pauses of greater or less duration, mainly —though not entirely—for the sake of clearness. If our remarks were then written down, these different pauses would be represented by different stops.

Marks of Punctuation. 1. Where we completed a sentence, a *period*, or *full stop*, would be used (.).

2. Where we made a decided pause, but not so decided as in the first case, a *colon* (:) or *semi-colon* (;) would be used.

3. Where only a slight pause was made, a *comma* (,) would be used.

These words are not strictly names of *stops*, but of the portions of sentences which they mark off. Thus, *period* means " a circuit," a complete sentence ; *colon* means " a limb," a member of a sentence ; and *comma* means " a section " of a sentence—something cut off, a clause. In Shakespeare *comma* has this meaning of a short part of a sentence. A *semi-colon* is a half-colon. The meaning of a sentence ought to be plain without the aid of any stops whatever. Stops are comparatively a modern invention ; they do not appear on ancient manuscripts, and at one time they were not allowed in our Acts of Parliament. At the present day, too, in legal documents stops are usually conspicuous by their absence.

Very often the entire meaning of a sentence can be altered by a slight alteration of punctuation—a fact of which full advantage is taken in many riddles that are propounded, and in many traps that are set for the unwary. Thus, in the well-known statement, " King Charles walked and talked half an hour after his head was cut off," nonsense becomes sense by the insertion of a colon after " talked." Again :

" Every lady in this land
Has ten fingers on each hand
Five and twenty on hands and feet
This is true without deceit."

Further instances will occur to everybody. Who, for example, has not heard of the advertisement, "A piano for sale by a lady about to cross the Channel in an oak case with carved legs" ?

Uses of the Stops. The *full-stop* is used to mark the completion of a whole sentence, whether simple or complex. It is also used after abbreviations—as *i.e.*, R.S.V.P., Rev., D.D.

The *colon* originally marked off the parts of a compound sentence. It is now used after a sentence which, though grammatically complete, is followed by another sentence closely connected in sense. In such cases a full-stop would mark too great a break. For example, in Sir Walter Scott's "Autobiography": " My father had a zeal for his clients which was almost ludicrous : far from coldly discharging the duties of his employment towards them, he thought of them, etc."

Again :

" Cowards die many times before their deaths :
The valiant never taste of death but once."

A colon is also used to introduce a quotation. For example : A forgotten satirist well says :

" The active principle within
Works on some brains the effect of gin."
(Lockhart's "Life of Scott.")

The *semi-colon* is a modern form of the colon. It is impossible to lay down rules for their respective use, but, roughly speaking, the semi-colon marks a less complete pause than the colon. The semi-colon is usually placed between the co-ordinate members of a compound sentence *when the connection is marked by a conjunction*—as : " Thou dost here usurp the name thou owest (ownest) not ; and hast put thyself upon this island as a spy " ("Tempest"). If the sentences are short, and closely connected in meaning, commas are used instead of semi-colons—as :

" We carved not a line, and we raised not a stone,
But we left him alone in his glory."

Sometimes not even a comma is needed—as :

" He was born and died in London."

The *comma* is not used to-day as frequently as in former days. A sentence should not be overloaded with commas ; they should be used only where it is absolutely necessary for the sake of clearness. Common-sense must be the guiding element in their usage. But a few points may be mentioned :

1. A comma should be used to mark the end of a substantive clause forming the *subject* of a verb—as : " That the days are longer in summer than in winter, admits of no dispute." But if the clause either follows the verb, or is the object of the verb, no comma is used—as : " He said that he was cold."

2. In a list of words of the same nature—nouns, adjectives, adverbs, etc.—brought together in the same connection, a comma is inserted after each word except the second last when it is followed by " and "—as : " With an humble, lowly, penitent and obedient heart " (Prayer Book).

3. The comma is used after an adverbial clause that comes before the verb which it modifies—as : "When he comes, tell me." But if the adverbial clause *follows* the verb, the comma is not needed—as : "Tell me when he comes."

4. There is no need of a comma between the antecedent and the relative pronoun if the relative introduces a limiting, or restricting, clause ; but if the relative is continuative or ampliative [see page 607] a comma must be introduced. The two examples quoted on page 607 well illustrate this :

Restrictive. "He broke the pen which I lent him."

Continuative. " His eldest son, whom he had lost many years before, had always been his favourite."

5. A comma is used to separate a noun in the Vocative (or Nominative of Address) from the rest of the sentence—as : "Thou spirit, who led'st this glorious eremite into the desert." (Milton.)

Continued

FRENCH

Continued from page 1188

By Louis A. Barbé, B.A.

POSITION OF ADJECTIVES

1. It very largely depends upon euphony whether an adjective is to be placed before or after the noun which it qualifies. In accordance with it, the following general principle may be laid down: monosyllabic nouns are seldom preceded by adjectives of several syllables.

2. Use has established the following rules:

(*a*) The adjectives *beau*, beautiful; *bon*, good; *cher*, dear (loved); *gentil*, pretty, nice; *grand*, large; *gros*, big; *jeune*, young; *joli*, pretty; *long*, long; *mauvais*, bad; *meilleur*, better; *petit*, small; *pire*, worse; *sot*, stupid; *vaste*, vast; *vieux*, old; *vilain*, ugly, usually precede the adjective.

(*b*) The ordinal numbers: *premier*, first; *deuxième* and *second*, second; *troisième*, third, etc., and also *dernier*, last, are placed before the noun; *le premier homme*, the first man; *le vingtième siècle*, the twentieth century. In connection with *semaine*, week; *mois*, month; *année*, year; *siècle*, century, the adjective *dernier* changes its meaning according as it comes before or after the noun, thus: *la semaine dernière*, last week; *l'année dernière*, last year—*i.e.*, immediately preceding the present week, etc. When it is placed before the noun it indicates the last of a particular series, thus: *la dernière semaine du mois*, the last week of the month; *le dernier jour de l'année*, the last day of the year.

(*c*) Adjectives of colour, as *rouge*, red; of shape, as *rond*, round; of taste, as *amer*, bitter; of temperature, as *tiède*, tepid; of nationality, as *français*, French; and of religion, as *protestant*, are placed after the noun, as: *une fleur blanche*, a white flower; *une table carrée*, a square table; *une pomme douce*, a sweet apple; *de l'eau froide*, some cold water; *un soldat anglais*, an English soldier; *un pasteur protestant*, a protestant clergyman.

(*d*) Present participles (which then become verbal adjectives) and past participles follow nouns when they are used to qualify them: *une main tremblante*, a trembling hand; *un homme instruit*, an educated man.

(*e*) Adjectives which end in *al*, *el*, *ic*, *ique*, *able*, *aire*, *oire*, and *ible*, and which are consequently polysyllabic, usually follow the noun: *un voyage sentimental*, a .sentimental journey; *un homme spirituel*, a witty man; *un parc public*, a public park; *une réponse catégorique*; a categorical reply; *une femme remarquable*, a remarkable woman; *une dépense nécessaire*, necessary expense; *un ordre péremptoire*, a peremptory order; *un remède infaillible*, an infallible remedy.

(*f*) A change from the literal to a figurative meaning is usually indicated by a change of position: *un habit noir*, a black coat; but *une noire ingratitude*, black ingratitude.

(*g*) In accordance with this, some adjectives in connection with certain nouns have very different meanings, according as they come before or after the noun. This is particularly the case in connection with *homme*:

Un bon homme, a simple, good-natured, man; *un homme bon*, a kind-hearted, charitable man; *un brave homme*, a worthy man; *un homme brave*, a courageous man; *un pauvre homme*, a man of mean capacity; *un homme pauvre*, a man in poor circumstances; *un galant homme*, a chivalrous man; *un homme galant*, a man attentive to ladies; *un honnête homme*, an honourable man; *un homme honnête*, a polite man; *un cruel homme*, a disagreeable man; *un homme cruel*, a cruel, inhuman man.

EXERCISE VIII.

1. The young man's sister has pretty little children.
2. The old houses have large gardens.
3. The month of December (*décembre*) is the last month of the year.
4. He bought (has bought, *acheté*) an ugly, big dog last week.
5. They live (*demeurent*) in a large white house near the ruined (*ruiné*) castle (*château*).
6. There are two round tables in the little square room.
7. Have you any red ink ?
8. No; but I have some black ink and some blue ink.
9. The French language is a romance (*romane*) language.
10. Spain (*l'Espagne*) is a Catholic country; England and Scotland (*l'Ecosse*) are Protestant countries.
11. The child took (*prit*) the money (*argent*) with (*de*) a trembling hand.
12. The old church is near the public park.
13. The French clergyman is a very intelligent and very learned man.
14. There are no infallible remedies.
15. A worthy man is not always (*toujours*) a courageous man.
16. A rich man may (*peut*) be a man of mean capacity.
17. A broad (*large*) and deep (*profond*) ditch (*fossé*, m.) protects (*défend*) the approach (*approche*) of the old castle.
18. Paris is a large and handsome city.
19. They have met with (*rencontré*) insurmountable (*insurmontable*) difficulties (*difficulté*).
20. We have spoken to a very amiable young man.

DEGREES OF COMPARISON

1. There are three degrees of comparison: the positive (*le positif*), the comparative (*le comparatif*), and the superlative (*le superlatif*). The positive is the adjective in its simple form—*bon*, *petit*, *mauvais*.

2. **The Comparative.** There are three forms of the comparative: (*a*) the comparative of superiority, (*b*) the comparative of inferiority, and (*c*) the comparative of equality.

(*a*) The comparative of superiority is formed by putting *plus*, more, before the positive, and *que*, than, after it: *Le chien est plus grand que le chat*, the dog is bigger than the cat.

(*b*) The comparative of inferiority is formed by putting *moins*, less, before the positive and *que*, than, after it: *Le chat est moins grand que le chien*, the cat is less big than the dog.

(*c*) The comparative of equality is formed by putting *aussi*, as, before the positive and *que*, as, after it: *Le chat est aussi grand que le chien*, the cat is as big as the dog.

When the comparative of equality is used in a negative sentence *si* may take the place of *aussi*: *Le chat n'est pas si grand que le chien*, the cat is not so big as the dog.

3. **The Superlative.** There are two kinds of superlative—(*a*) the relative superlative, and (*b*) the absolute superlative.

(*a*) The relative superlative is that which, besides expressing a quality in the highest or lowest degree, indicates a comparison between that quality in one object, or class of objects, and the same quality in another object, or class of objects.

The relative superlative may be a superlative either of superiority or of inferiority.

The superlative of superiority is formed by putting the definite article *le*, *la*, or *les* before the comparative of superiority: *L'éléphant est le plus fort des animaux*, the elephant is the strongest of animals; *elle est la moins jolie des trois sœurs*, she is the least pretty of the three sisters.

When the superlative is preceded by a possessive adjective, the article is left out: *Mon plus beau tableau*, my finest picture.

When the superlative adjective comes immediately after the noun, two articles are required—one before the noun, the other before the superlative: *Les animaux les plus féroces*, the most ferocious animals; *les hommes les moins intelligents*, the least intelligent men.

In this construction when there is a possessive it takes the place of the first article only: *Mes élèves les plus avancés*, my most advanced pupils. When there is a preposition before the superlative it affects the first article only: The opinion of the most intelligent men, *l'opinion des hommes les plus intelligents*.

The preposition "in," which frequently follows the superlative in English, is rendered by *de* in French: The most beautiful flower in the garden, *la plus belle fleur du jardin*.

The English rule with regard to the use of the comparative when only two objects are compared, and of the superlative when more than two are compared, is unknown in French: The taller of the two, *le plus grand des deux*; the tallest of the three, *le plus grand des trois*.

"More than," "less than" before a numeral do not necessarily imply a comparison, but only excess or want. In that case they are expressed by *plus de*, *moins de*: He has more than three francs, *il a plus de trois francs*. When there is a real comparison, in which case the verb is understood after the numeral, "than" is rendered by *que*: Two dogs eat more than four cats (eat), *deux chiens mangent plus que quatre chats*.

(*b*) The absolute superlative is that which carries the quality of an object to the highest (or lowest) degree, but does not imply a comparison with any other object. It is formed by putting some such word as *très*, very; *bien*, very; *fort*, greatly; *extrêmement*, exceedingly, etc., before the adjective. *Le plus*, most, and *le moins*, least, may also be used absolutely; but, in that case, the definite article *le* is invariable.

4. **Irregular Comparisons.** (*a*) The adjective *bon*, good, is compared irregularly: *bon*, good; *meilleur*, better; *le meilleur*, best.

(*b*) *Petit*, small, has both a regular and an irregular comparison: *petit*, small; *plus petit*, smaller; *le plus petit*, smallest; and also *petit*, small or little; *moindre*, less; *le moindre*, least. The regular form is used to express size: *le plus petit des enfants*, the smallest of the children. The irregular form is more commonly used with reference to importance, value, etc.: *le moindre soupçon*, the least suspicion.

(*c*) *Mauvais*, bad, has both a regular and an irregular comparison: *mauvais*, bad; *plus mauvais*, worse; *le plus mauvais*, worst; and also, *mauvais*, bad; *pire*, worse; *le pire*, worst. The regular form indicates the actual badness of an object: *La bière est plus mauvaise que le vin*, the beer is worse (*i.e.*, of worse quality) than the wine. The irregular form refers more particularly to evil effects, unpleasant consequences, etc. Thus, to express the bad results of over-indulgence in beer and wine respectively, it might be said: *la bière est pire que le vin*, beer is worse than wine.

5. **Irregular Adverbs.** In English these forms of comparison are used both as adjectives and adverbs, thus: His writing is *better* than mine, and, He writes *better* than I. In French, the two parts of speech are different, and must be carefully distinguished from one another:

ADJECTIVE: *Bon*, good; *meilleur*, better; *le meilleur*, best;

ADVERB: *Bien*, well; *mieux*, better; *le mieux*, best.

ADJECTIVE: *Petit*, little; *moindre*, less; *le moindre*, least;

ADVERB: *Peu*, little; *moins*, less; *le moins*, least.

ADJECTIVE: *Mauvais*, bad; *pire*, worse; *le pire*, worst;

ADVERB: *Mal*, badly; *pis*, worse; *le pis*, worst.

Mal has also the regular forms *plus mal*, *le plus mal*.

EXERCISE IX.

1. The horse is bigger than the ass (*âne*), as big as the ox (*bœuf*), and less big than the elephant.
2. Cats are not so faithful (*fidèle*) as dogs.
3. The tiger is the most ferocious of animals.
4. My finest pictures and my best books are not here (*ici*).

5. Here is the best known (*connu*) of Dumas' novels (*roman*, m).

6. He lives in the smallest house in the village (*village*, m).

7. The least difficulty discourages (*décourage*) lazy (*paresseux*) pupils.

8. He has spent (*passé*) more than three months in France.

9. Three cats eat less than two dogs.

10. The wolf has eaten (*mangé*) more than three sheep.

11. Gold is less useful than iron ; gold is the most precious (*précieux*), but iron is the most useful of metals.

12. The highest (*élevé*) mountain (*montagne, f.*) in Scotland is (has) more than four thousand (*quatre mille*) feet.

13. There is one of the most intelligent pupils in the class.

14. The prettier of the two sisters is not the more amiable.

15. The most bitter fruits are often the most wholesome (*sain*).

16. The remedy is often worse than the evil (*mal*, m.).

17. Doctors (*médecin*) are more useful than barristers (*avocat*).

18. We have (one has = *on a*) often need of one smaller than ourselves (oneself = *soi*).

Key to Exercise VI. (page 1187).

Je regarde par la fenêtre. Devant la fenêtre il y a un grand jardin. Dans le jardin il y a des arbres. Parmi les arbres il y a un bel aubour, un joli lilas, une aubépine, une yeuse et un sorbier. Il y a aussi de grands lauriers. Ils sont toujours verts. L'yeuse aussi est toujours verte. En automne le sorbier a des baies. Elles sont rouges. En hiver le houx a des baies aussi. Les feuilles du houx sont luisantes et piquantes. Au printemps le houx et le sorbier n'ont pas de baies. Au delà des arbres je vois un pont. Sous le pont il y a une petite rivière. L'eau de la rivière est fraîche et claire. Au delà du pont il y a une large rue. La rue a deux trottoirs. Au bord des trottoirs il y a des réverbères. Dans la rue il y a plusieurs personnes. Elles marchent sur le trottoir. Une des personnes est un facteur. Il a un sac plein de lettres. Il y a aussi une voiture et un cheval. Il n'y a pas de charrette. Au bout de la rue il y a une église. Elle a un beau clocher. Le clocher est haut. Il a une girouette. L'église n'est pas vieille, elle est nouvelle. De la fenêtre je vais à la table. Je prends un petit livre. La couverture du livre est bleue. Dans le livre il y a de jolies gravures. Une des gravures représente une ferme. La ferme est dans une grande cour. Elle a une écurie et une étable. Dans l'étable il y a des vaches. La vache donne du lait. L'écurie est la maison du cheval. L'écurie n'est pas un grand bâtiment. Dans l'écurie il y a un jeune cheval et un vieille jument. Près de la ferme il y a un pré. Dans le pré il y a des brebis. Une petite fille garde les brebis. La brebis donne de la laine. La laine de la brebis est utile à l'homme. Derrière la ferme il y a un verger. Dans le verger il y a des pommiers, des poiriers et des cerisiers. Les pommes sont le fruit du pommier. Les pommes sont bonnes quand elles sont mûres. Les cerises sont le fruit du cerisier. Elles sont douces. Les poires sont savoureuses. J'aime la campagne. En été je vais à la campagne. J'ai une petite maison sur une colline agréable. Elle est blanche. Les contrevents sont verts. Le toit est de chaume. Elle est propre et gaie. A la campagne l'exercice donne un nouvel appétit. La faim est une bonne cuisinière. Les mets sont fins. Les repas sont des festins. En hiver je n'aime pas la campagne. Elle est nue et triste. Les arbres n'ont pas de feuilles. Il y a de la neige sur la terre. En hiver j'aime la ville.

Key to Exercise VII. (page 1188).

1. Voilà de beaux livres.
2. Les enfants sont polis.
3. Vous avez de belles oranges.
4. Les bateaux ont des gouvernails.
5. Les pêches et les abricots ont des noyaux.
6. Nous avons donné des prix aux élèves.
7. Les portes n'ont pas de verrous.
8. Les joujoux des enfants sont cassés.
9. Les bijoux de la princesse ont coûté des prix fous.
10. Il y a des choux dans le jardin.
11. Les bergers gardent les troupeaux.
12. Les chevaux sont des animaux utiles.
13. Il n'y a pas de chacals en Angleterre.
14. Les églises ont de beaux vitraux.
15. Les généraux ont des aïeux nobles.
16. Nous n'avons pas besoin d'éventails.
17. Les petites filles ont les yeux bleus.
18. Ils ont donné plusieurs bals.
19. La voûte des cieux est parsemée d'étoiles.
20. Les travaux des hommes sont périssables.

Continued

GERMAN

Continued from page 1191

By P. G. Konody and Dr. Osten

XIV. 1. The Past Participle of Weak Verbs is generally formed by the prefix ge- and the suffix -t or -et.

The prefix ge- cannot be added to verbs of foreign origin, like the extensive group of verbs ending in -ieren, (addie'ren, to add up; citie'ren, to quote; regieren, to reign, govern; etc.), and to verbs with unstressed first syllables (such as those with the prefixes be-, emp-, ent-, er-, ge- ver-, zer-)

Examples: lob-en, ge-lob-t; lern-en (to learn), ge-lern-t; but regieren, regier-t; begrü'ßen, (to greet), begrüß-t; erlauben, (to permit, allow), erlaub-t; etc.

2. The Present Participle of all German verbs is formed by the suffix -end: lob-end, praising; lern-end, learning; red-end, ſprech-end, speaking; etc.

Note. The Progressive Form (auxiliary verb and participle present) is *never* used in

German. "I am coming" is expressed by „ich komme" (I come), *never* by „ich bin kommend"; "I was learning," „ich lernte" (I learned), *never* „ich war lernend".

3. The **Imperative** (mood of command, desire, and wish) is formed in the weak conjugation by the suffixes -e (*sing.*) and -et or -t (*plur.*).

2. *sing.* lob-e! } praise! lern-e! } learn!
2. *plur.* lob-et! } praise! lern-et! } learn!
civil address lob-en Sie! lern-en Sie!

The suffix -e in the *sing.* and the flective e in the second person *plur.* can in some cases be omitted, but not in verbs with stems ending in d or t, *e.g.*, bad-e! bad-et!, bathe!; red-e! red-et!, speak!

For the sake of emphasis the personal pronoun is sometimes added, either before or after the verb: Du, lerne! or Lerne du! — Ihr, lernet! or Lernet ihr!

4. As in English, the imperative for the first and third person is formed with the help of auxiliary verbs. There are either auxiliary verbs of tense (ſein, haben, werden), or of mood *: ſoll-en, ich ſoll (I am to); mög-en, ich mag (I may); müſſen, must; woll-en, ich will (I will, I want to, I wish to); laſſ-en (to let, to allow, to permit, etc.). They are used in the indicative and conjunctive moods, the subject either preceding or following the *finite* verb.

Examples: Seien wir glücklich! — Let us be happy! Möge [pres. conj.] ich (er) glücklich ſein! — May I (he) be happy! Mag er kommen! — May he come (let him come!) Laſſet uns fleißig ſein! — Let us be diligent! Ihr ſollt (müßt) lernen! — You ought to (must) learn! Es werde Licht! — Let there be light! Er lebe! — May he live! Möchte** es ihm gelingen! — May he succeed with it! (*lit.*: May it him succeed).

5. The auxiliary verbs of mood: mögen, may, and laſſen, let, and the conjunctive forms are used where the imperative expresses a wish, desire, or hope; whilst the indicative denotes command. To distinguish this indicative of command from the indicative of the ordinary statement, the sequence of words in the former case is the same as in a sentence of question [see IX.]: Mag er kommen! May he come (let him come!) but: Er mag kommen, he may come.

XV. 1. **Prepositions.** The German prepositions govern either the genitive (2), the dative (3), or the accusative (4), or in some cases the two latter alternately, whilst a few govern the genitive and dative alternately. Examples (the governed case is indicated by the figures in brackets): ſtatt, anſtatt (2), instead of; wegen (2), on account of, because of; aus (3), out of, from; bei (3), near, about, with, at, by; mit (3), with; nach (3), after, to, for; von (3), from, of; zu (3), to, at, by; für (4), for; gegen (4), against, towards; ohne (4), without; durch (4), through, by; um (4), around, about, for. The exact employment of these prepositions must be learnt by practice. What the student has to commit to memory is the case governed by each.

The prepositions governing two cases will be treated subsequently.

Examples: Er redete ſtatt (2) meiner — he spoke instead of me. Ich komme wegen (2) des Schülers — I come on account of the scholar. Wir kommen aus (3) dem Garten — we come from the garden. Ich war mit (3) dem Vater — I was with the father. Er kommt nach (3) Ihnen — he comes after you. Es iſt für (4) das Kind — it is for the child. Wir ſegelten gegen (4) den Wind — we sailed against the wind. Er arbeitete ohne (4) mich — he worked without me. Wir wanderten durch (4) den Wald — we walked through the forest.

XVI. 1. **The Strong Declension** [see V. and VI.] is chiefly taken by the masculine, the majority of the neuter, and a few feminine nouns ending in -s, -ſt, -t (die Maus, the mouse; die Nuß, the nut; die Kunſt, the art; die Braut, the bride; etc.) -nis and -ſal (die Kenntnis, the knowledge; die Trübſal, the affliction; etc.) As the nouns of feminine gender remain unaltered in the singular of both the strong and the weak declension, the formation of the plural provides the only clue as to the group to which they belong. The feminines of the strong declension, except those ending in -nis and -ſal modify the vowel in the plural.

2. The characteristic feature of the strong declension of masculine and neuter nouns [see VI.] is the suffix -es or -s in the genitive. The -s inflection is taken by nouns

(*a*) ending in an unstressed -e,
(*b*) ending in the unstressed syllable -el, -em, -en, or -er,
(*c*) some substantives of foreign origin,
(*d*) all diminutives [see XII., 1*c*, and Table VI$_5$].

Examples: (*a*) das Gewöl'be, des Gewölbe-s, (vault); (*b*) der Sattel, des Sattel-s, (saddle); der Athem, des Athem-s, (breath); der Magen, des Magen-s, (stomach); der Fiſcher, des Fiſcher-s, (fisherman); (*c*) das Ventil', des Ventil-s, (valve); der Tenor', des Tenor-s (the tenor); (*d*) das Vä'terchen, des Väterchen-s.

3. All other strong substantives take -es in the genitive, but the e is sometimes dropped in nouns that do not have the stress on the last syllable—*e.g.*, der Kö'nig, des König-s (king); der A'bend, des Abend-s, (evening); der Fähnrich, des Fähnrich-s, (ensign); but der Mann, des Mann-es. Nouns with stressed final syllables ending in e drop the *flective* e for reasons of euphony: der Klee, des Klee-s, (clover); das Knie, des Knie-s, (knee). The flective e can also be dropped in the *dative* of nouns ending in hissing sounds (s, ſſ, ß, ſch, z): das Gras (grass), des Graſ-es, dem Graſ-e *or* dem Gras; der Fluß (river), des Fluſſ-es, dem Fluſſ-e *or* dem Fluß; der Wunſch (wish, desire), des Wunſch-es, dem Wunſch-e *or* dem Wunſch; der Tanz (dance), des Tanz-es, dem Tanz-e *or* dem Tanz.

XVII. The **Possessive Pronouns** are: mein, my; dein, thy; ſein, his; ihr, her; ſein, its; unſer, our; euer, your; ihr, their; each with three genders and a uniform plural for all the three genders. The suffixes shown in the following table serve for *all* possessive pronouns:

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* Denotations of will, command, wish, desire, ability, obligation, etc., which in their varying sense cannot be exactly translated into English.

** Imp. conj. of mögen.

Singular.			
1.	mein (*m.*)	mein-e (*f.*)	mein (*n.*)
2.	mein-es	mein-er	mein-es
3.	mein-em	mein-er	mein-em
4.	mein-en	mein-e	mein

Plural.	
1.	mein-e
2.	mein-er
3.	mein-en
4.	mein-e

1. The declensive e (*or* the radical e) is sometimes dropped in the declension of unſ-e-r and eu-e-r: unſ(e)r-es or unſer-(e)s; eu(e)r-es or euer-(e)s; unſ(e)r-em or unſer-(e)m; eu(e)r-em or euer-(e)m; etc.

2 The possessive pronoun agrees in gender, number and case with the substantive, when it precedes this substantive (as attributive adjective): mein Hut, my hat; dein-e Weſte, your waistcoat; ſein Hemd, his shirt; der Hut mein-es Vaters, mein-er Mutter, mein-es Kindes, the hat of my father, of my mother, of my child.

3. The third person ſein (*m.* and *n.*) his, and ihr (*f.*) her, agrees in gender with the substantive which it substitutes, but in number and case with the noun it precedes; for instance: der König liebt ſein-en Sohn und ſein-e Töchter, the king loves his son and his daughters.

EXAMINATION PAPER V.

1. Which prefix and suffix are employed in the formation of the weak past participle?
2. Which are the cases where this prefix cannot be employed, and how is the past participle formed in these cases?
3. Name the unstressed prefixes of German verbs.
4. Which suffix is used for the formation of the present participle of all German verbs?
5. How do the familiar and the civil form of address differ in the imperative of the second person singular?
6. When is the imperative formed by the aid of auxiliary verbs of tense, and when by auxiliary verbs of mood?
7. Are the prepositions subject to declension?
8. Which feminine nouns belong to the strong declension, and what are their terminations?
9. How do you judge whether a feminine noun belongs to the weak or the strong declension?
10. What is the gender of the majority of strong nouns?
11. Which strong nouns form the genitive sing. with the suffix -s, and which with the suffix -es?
12. When is the flective -e omitted, and when retained, in the genitive and dative?
13. Which are the German possessive pronouns?
14. Are there any distinctions of gender in the plural of the possessive pronouns?
15. Where is the possessive pronoun placed when used as attributive adjective?
16. With which substantive do ſein and ihr (her) agree in gender, and with which in number and case?

Exercise 1. (*a*) Form the present and past participles of the following verbs, after having ascertained the stem:

ahnen,	to forebode,
arbeiten,	to work,
athmen,	to breathe,
baden,	to bathe,
begrüßen,	to greet,
belächeln,	to smile at, upon,
erlauben,	to allow,
erzählen,	to narrate,
entzücken,	to charm (ravish),
erröthen,	to blush,
eröffnen,	to open (inaugurate),
gähnen,	to yawn,
gehorchen,	to obey,
gewähren,	to grant,
handeln,	to act,
haſſen,	to hate,
koſten,	to taste, to cost,
läuten,	to ring,
lieben,	to love,
loben,	to praise,
lernen,	to learn,
lauſchen,	to listen,
lächeln,	to smile.
öffnen,	to open,
rauchen,	to smoke.
rechnen,	to reckon, to calculate,
reden,	to talk, speak,
regieren,	to govern.
röſten,	to roast.
ſagen,	to say,
ſegeln,	to sail.
ſchnalzen,	to smack [one's tongue]
ſpielen,	to play, to gamble.
ſtören,	to disturb.
verſagen,	to refuse.
verſpielen,	to lose [at play].
zählen,	to count,
zeichnen,	to draw,
zerſtören.	to destroy.

(*b*) Insert the missing imperatives:

(*sing.*) ...... die Aufgabe! (*pl.*) ...... den Vater!
Learn the lesson! Greet the father!
(*s.*) ...... die Thür! (*pl.*) ..... ruhig!
Open the door! Be quiet!
(*s.*) .... beten! (*pl*) ....! (*s.*) .... die Glocke!
Let us pray! Pray! Ring the bell!
(*conj. pres. of to be*) ...... wir ruhig!
Let us be quiet!

Exercise 2. Insert the missing substantives and pronouns in the cases required by the prepositions.

Die Mutter kommt ſtatt ....
The mother comes instead of the father.
Wir wanderten mit .... durch ....
We walked with the children through the wood.
Er reiſte gegen .... des Onkels
He travelled against the wish of the uncle
wegen .... Er kommt aus ... .
on account of the aunt. He comes from the south
und bringt Geſchenke für ..., für ... und für ... .
and brings presents for me, for him and for the girl.
Der Lehrer lobte uns nach .... Prüfung
The teacher praised us after the examination.
Er kommt nach .... ohne ....
He comes after [the] dinner without a guide
durch ... . Wir beteten für ... .
through the forest. We prayed for the uncle
und für .... nach .... Predigt (*f.*)
and for the aunt after the sermon.
Ich hörte eine Rede ſtatt ....
I heard a speech instead of a song.

Exercise 3. Insert the missing inflections of the strong genitive -es or -s.

Der Rahmen des Gemälde.. und die Decke des
The frame of the picture and the ceiling of the

Gewölbe.. waren dunkel. Die Farbe des Käſe..
vault were dark. The colour of the cheese
iſt gelb. Er holte den Griff des Säbel.. und den
is yellow. He fetched the hilt of the sword and the
Bügel des Sattel .. aus dem Winkel des Zimmer..
stirrup of the saddle from the corner of the room.
Der Vater des Mädchen .. und des Knäblein.. iſt
The father of the girl and of the (*dimin.*) boy is
der Beſitzer des Schloſſ... und des Wagen..
the proprietor of the castle and of the carriage.
Der Anfang des Tag..., des Monat.. und des
The beginning of the day, the month, and the
Jahr...; die Strahlen des Mond... und des
year; the beams of the moon and of the
Abendſtern... Die Frau des Major.. ſah die
evening star. The wife of the major saw the
Weiber des Mogul.. im (3) Garten des Palaſt...
wives of the mogul in the garden of the palace
im (3) Lichte des Mond... Der Geſchmack des Salz...
in the light of the moon. The taste of the salt
und des Pfeffer.. war bitter; die Süßigkeit des
and pepper was bitter; the sweetness of the
Punſch... und des Thee.. war die des Zucker..
punch and of the tea was that of (the) sugar
oder des Honig:s. Die Farbe des Band... und des
or honey. The colour of the ribbon and of the
Tuch... hob die Weiße des Halſ...
shawl raised (intensified) the whiteness of the neck
des ſchönen Töchterchen.. unſeres Wirth...
of the beautiful (*dimin.*) daughter of our host.
Die Zeit des Schrecken.. und des Blutdurſt... füllte
The time of terror and of bloodthirstiness filled
alle Räume des Kerker.. und des benachbarten
all the rooms of the prison and of the neighbouring
Gebäud... mit (3) den Gefangenen des Her'zog.. und
building with the prisoners of the duke and
ſeines Günſt'ling.., des Mini'ſter..
of his favorite, the minister.

EXERCISE 4. (*a*) Replace the definite and the indefinite article in Examination Paper II., page 750 (where the nature of the substantive admits it), by the pronouns mein, dein, ſein, ihr (her) in the corresponding genders. (*b*) Insert the missing possessive pronouns in the following sentences:

.... Vater, ... Mutter und ... Bruder kommen
My father, my mother and my brother come
heute. ... Rock, ... Weſte und ... Hemd
to-day. Your coat, thy waistcoat and his shirt
ſind hier. Der Bruder ..... Frau iſt ....
are here. The brother of my wife is my
Schwager. .... Sohn ſpaziert mit der Tochter
brother-in-law. Our son walks with the daughter
..... Freundes in ..... Garten. Sie verkaufte ....
of our friend in his garden. She sold her
Wagen (*m.*), ... Pferde (*n.*) und ... Haus (*n.*), und
carriage, her horses, and her house, and
entließ .... Kammerjungfer und .... Diener (*m.*).
dismissed her chambermaid and her servant.
.... Kutſcher fährt vorzüglich mit (3) .... Pferden.
Your coachman drives excellently with our horses
(drives our horses splendidly).
Der Freund .... Mutter iſt auch der Freund ....
The friend of his mother is also the friend of our
Hauſes (*n*). Der König liebt .... Sohn und ....
house. The king loves *his* son and *his*
Tochter; die Königin liebt .... Sohn und ....
daughter; the queen loves *her* son and *her*
Tochter; der Prinz liebt .... Vater und ....
daughter; the prince loves *his* father and *his*
Mutter; die Prinzeſſin liebt .... Vater und ....
mother; the princess loves *her* father and *her*
Mutter. Der König iſt ſicher inmitten (2) .....
mother. The king is safe in the midst of *his*
Volkes; die Königin iſt ſicher inmitten .....
people; the queen is safe in the midst of *her*
Volkes; das Kind des Königs iſt ſicher inmitten
people; the child of the king is safe in the midst
.... Volkes. Der Lehrer lobte ..... Schüler
of *its* people. The teacher praised his pupil (*m.*)
und .... Schülerin in .... Gegenwart (*f.*) in (3) ....
and his pupil (*f.*) in our presence in your (*pl.*)
Hauſe. Er ſprach mit (3) .... Sohne und mit (3)
house. He spoke with his son and with
.... Tochter von (3) .... Plänen (*m.*) und von ....
his daughter of their plans and of their
Wunſche zu reiſen.
desire to travel.

Continued

continued from page 1219

THE SCULPTOR'S OUTFIT

Action and Form of Animals. Making the Armature. Setting out the Scale for Measurements of the Subject. Putting on the Clay. Anatomical Models

By COURTENAY POLLOCK, R.B.A., and P. G. KONODY

Action and Proportion. It may simplify matters to divide animal drawing into two distinct studies—action and form. The early study of action will impress upon the memory the general appearance of the animal and its manner of movement. If you face the animal with paper and pencil, don't wait for the model to "pose" or settle down, which would be sheer waste of time. Begin at once to draw; look at the model long and carefully, noting the proportions and general outline only. Then put on paper what you recollect. There is no need to make large studies—4 in. sq. will be found a convenient size. If the model should happen to move, don't wait for a return to the same position, but leave the note as it is, and make another.

In this way you will fill your book with odd and seemingly incomplete studies. But these will prove most valuable, and every bit of drawing is so much knowledge gained. The chief point is to look well at the model before putting pencil to paper — say, ten seconds for five seconds' drawing. Use a soft pencil, and don't hesitate. Each time draw the whole animal, if possible, and you will quickly grasp the action and proportions. Use few lines, but let none of them be meaningless. Shading is unnecessary, as a rule, and should only be used to explain the form, but avoided when movement can be expressed without it.

Form. In drawing form, it is best to confine attention to some particular part of the animal, and again to leave each study as soon as the animal moves, even if it be after a couple of strokes. Keep to one part until you have learnt something of it, and draw it in as many positions as possible. But you must look carefully and put down only what you are sure you have seen. One hour of this system will teach you much.

For students living in London, the Zoo will afford ample opportunity for study. Permission to enter for this purpose may be obtained on application to the Superintendent. Those who live in the country will, of course, have to confine themselves to such animals as they find around them. But the student can learn as much from these as from any others. If he really wishes to learn, the difficulties are, after all, not very great. One can generally come to an understanding with an omnibus or cab proprietor, or a groom. Dogs and cats are at hand everywhere. Rabbits may be bought for a few pence, and threepence will buy a live rat at any market hall. The study of animal anatomy is essential for the mastering of animal drawing.

Modelling the Figure in Relief. The word "relief" is not used here to signify relief proper (which the student should not attempt at this stage), but to distinguish between modelling on a slab and modelling in the round. Slab work is recommended at first, because armatures can be dispensed with. Draw your outline on the clay, as in previous cases, and build

18. THE STATUE OF DAVID
By Michael Angelo

at the foot of the drawing a small shelf to form the ground on which the figure shall stand.

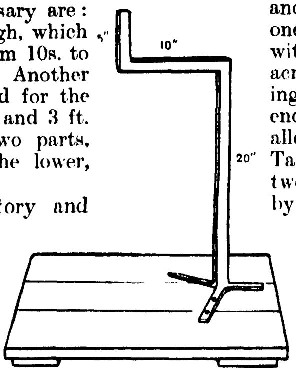
The "Round" Attached to the Slab. Put on the clay, not in the manner of low relief, but as if you were actually making a model in the round, attaching the figure to the clay background, and disregarding any temptation to foreshorten. Unhampered by constant movement, as in the case of animal study, you can work at greater leisure. A slab of about 15 in. by 24 in. will be found convenient for figure studies; the figure should not be less than 18 in. high.

It is absolutely necessary that the student should study artistic anatomy. Without a very thorough knowledge of anatomy, and of the changes of surface form resulting from different movements, it is impossible to become a thoroughly good sculptor.

Modelling in the Round. The first thing to consider in "modelling in the round" is the armature upon which the figure is to be built up, and the tools required. Let us take a figure half life-size—*i.e.*, between 32 and 34 in. high.

The tools and materials necessary are: A wooden turntable, 3 ft. 5 in. high, which has a revolving top, and costs from 10s. to 15s. This table is for the work. Another turntable, or rostrum, is required for the model. It should be 15 in. high and 3 ft. square, and must be made in two parts, the top half revolving upon the lower, costing about 25s.

It is generally more satisfactory and cheaper to have these things made by a joiner, but, to save trouble, they may be bought at an artists' repository. It is important that they be strongly made.



19. ARMATURE SUPPORT

A wooden board is required, about 18 in. square and 1 in. thick, with battens underneath, to prevent warping. Fix upon this with screws an iron upright of 1 in. in thickness, and 35 in. in length. Bend it to a right angle 20 in. from the foot. Along this bent piece measure off 10 in., and at this point bend it back again into the perpendicular. The foot should be splayed [as shown in **19**] into three feet, thus giving a good hold for the screws. With the 10 in. crank deducted, this will leave the upright 25 in. high.

About 12 ft. of "compo" tubing of ½ in. diameter, and about 9 ft. of galvanised wire, thin enough to bend easily in the fingers, is also wanted, as well as a hammer and a pair of pliers, a pair of callipers about 20 in. long, curved outwards in the middle so that the halves come together again at the points. These should be of steel; wooden callipers are easily broken. Have also half a dozen splinters of wood 1½ in. long, and a box of wooden matches, also a sheet of cardboard not less than 3 ft. long and 18 in. broad. Upon this board the scale will be drawn.

Making the Armature. Next comes the armature. For the legs cut off 53 in. of tubing, and bend it over the top of the upright, flattening it on to the iron support and binding it tightly, so that there are equal lengths upon either side. Bend them apart a little so that each will run through the centre of one leg [**20**]. Cut off the feet, so that the ends reach within ¼ in. of the board. All binding should be done in this way.

Take a piece of wire about 4 in. longer than will be required to reach twice round the pieces to be bound together. Bend this so as to double it, and again bend it in the middle. With the pliers give the end of the last bend one or two twists, then bind the free ends round the tubing, and with the pliers twist the ends, pulling it towards you, so as to tighten the binding. In this way one is able to tighten the binding, if necessary, by twisting the ends of the wire.

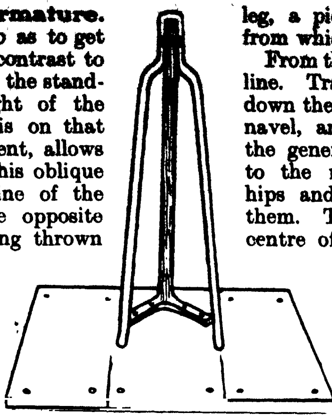
Now cut off a piece of tubing to support the trunk and shoulders, as shown in **21**, and another piece to support the head and strengthen the torso. Bind these pieces, as shown, to the 5 in. portion of the upright making the top flat for the shoulders. At the top of the back and neck-piece bend the tube into a small loop, to give plenty of attachment for the head. Take another length, enough to reach from one wrist to the other on the figure with outstretched arms. Bind this across the top of the shoulder, severing it in the middle and binding the ends to the upright piece of tubing, allowing the arms to fall downwards. Take the wooden splinters, and make two small crosses, or "butterflies," by crossing one upon the other, and binding with string. These should hang by the string from the shoulder-piece, one on either side of the backbone, and they should hang about the middle of the thorax, to support that mass [**22**].

The Scale. At the left-hand bottom corner of the board [**23**] take a point A and draw from it a straight line, horizontally—to the right. With the callipers take half the total height of the model, and, with A as centre, draw an arc from B. Take half the height of your figure, and, with B as centre, measure it off upon the arc, intersecting it at C. Now draw a straight line from A through C, and the scale is ready. When taking measurements, strike off the measurement of the model in the same manner as the arc BC was described, taking always A as centre. The corresponding measurement for the figure will be from the point of intersection on the line AB to the intersection on the line AC.

Now pose the model, and, with a piece of chalk, trace the outlines of the feet upon the rostrum, so that the position of the legs may be taken again without trouble.

Before putting any clay on the armature, give the tubing the same pose as the model, slightly exaggerating the action, and using the plumb-line to assist in keeping the balance of the figure. For the purpose of illustration we will take the pose of Michael Angelo's David [**18**].

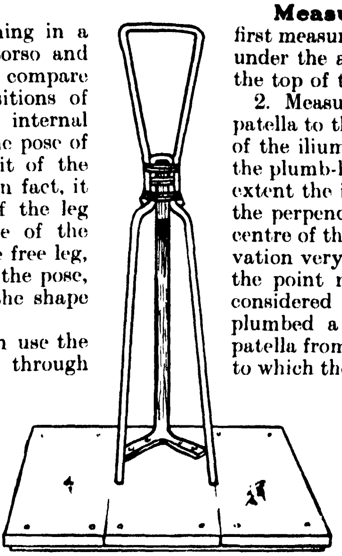
Action in the Armature. First bend the armature so as to get the action of the hips in contrast to the shoulders, and note that the standing leg (bearing the weight of the body) pushes up the pelvis on that side; the free leg, being bent, allows it to fall. In contrast to this oblique line of the pelvis, the line of the shoulders is thrust in the opposite direction by the trunk being thrown over, so that the weight is balanced over the standing leg. Thus, the pelvis falls downward from the standing leg, and the shoulders are thrown over to counterbalance this.



20. ARMATURE LEGS

Place a lump of clay on the piping where the pit of the neck will probably come, and mark this point by pushing in a wooden match. After bending the torso and getting the line of the shoulders, compare with the plumb-line the relative positions of the suprasternal notch with the internal malleolus of the standing leg. In the pose of David this line, dropped from the pit of the neck, strikes inside the malleolus—in fact, it divides the ankle. Bend the tube of the leg so that it will come down the middle of the limb, then bend out the piping of the free leg, giving the necessary curves to secure the pose, and following, as nearly as possible, the shape of the bones.

Take now the side view, and again use the plumb-line. Hold it so that it comes through the middle of the neck, and notice how it falls in relation to the external malleolus of the standing leg. The line of the back should be bent to coincide with the line of the spine, but a fair margin should be allowed for the clay. Block in the general form of the trunk, keeping the clay mass very much smaller than the proportions intended to be given to the figure. Cover the legs slightly with clay, and after bending the tubes of the arms cover them also with a thick coating of clay. Upon this foundation one will be able to mark the principal lines and measurements, the latter being fixed by means of matches.



21. ARMATURE WITH SHOULDERS

23. SCALE

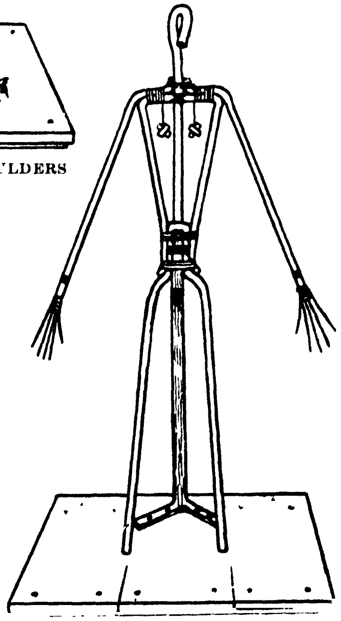
Now make the plinth of clay, which should be 3 in. deep. This will afford sufficient room to increase the length of the lower limbs, if necessary, without altering the work bestowed upon the upper portion. Place upon this, flush with the clay, and against the inside of the standing leg, a piece of wood, to give a firm point from which to take the first measurement.

From the suprasternal notch, draw the centre line. Trace it through the centre of the figure, down the sternum and linea alba, through the navel, and from there downwards, following the general internal line of the standing leg to the malleolus. Mark the centre of the hips and shoulders by drawing a line across them. Then turn to the back, and from the centre of the neck, at the point judged to locate the seventh cervical vertebra, draw the central line, following the vertebral column down to its base, and then through the general contour of the standing leg. Again mark the angles by the oblique pelvis and the shoulders, and indicate the oblique line of the fold of the buttocks.

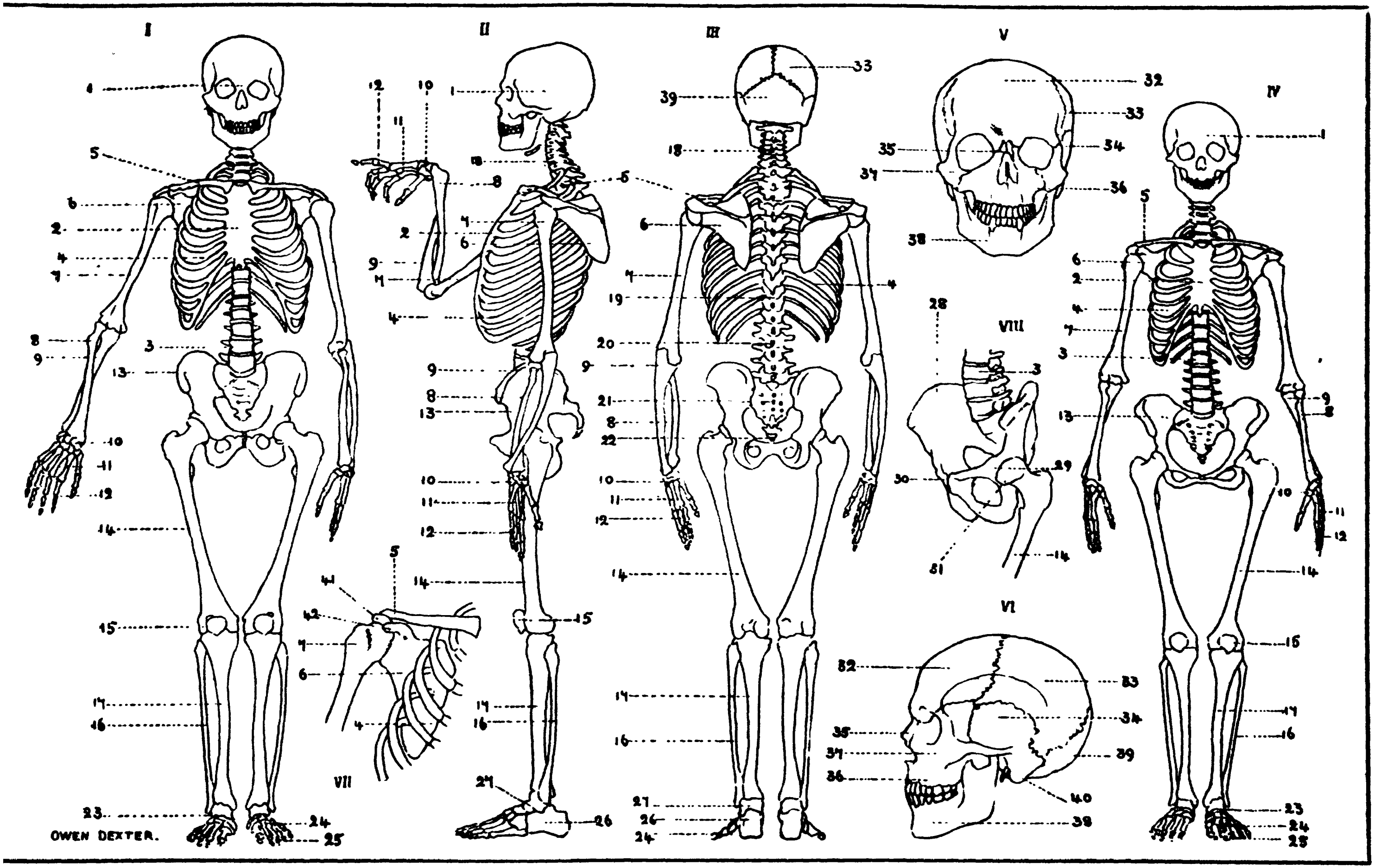
Measurements. 1. Take the first measurement from the plinth, just under the arch of the standing leg, to the top of the patella.

2. Measure from the top of the patella to the anterior superior process of the ilium of the standing leg. Use the plumb-line to find exactly to what extent the iliac process deviates from the perpendicular line drawn from the centre of the patella. Make this observation very carefully, and do not mark the point measured until it has been considered from the side, and having plumbed a perpendicular cutting the patella from the profile, note the extent to which the iliac process is in advance of the patella.

3. Measure the distance across from one iliac process to the other. Care must be taken to determine the angle of this line. To do this, hold a straight-edge up to the anterior superior



22. ARMATURE COMPLETE



24. PROPORTIONS OF THE HUMAN FRAME: BONES. [See opposite page]

process of the standing leg, and, keeping it perfectly horizontal, note how the iliac process of the free leg drops from this line.

4. Take the distance from the iliac process of the free leg to the top of the patella of the same leg.

5. From this point measure to the heel. The heel measurement may, like some of the others, be somewhat vague, therefore mark the point measured by a small spot of ink. This may be done when measuring points not marked by bone-form, such as the round, fleshy pad of the heel.

6. Measure from the anterior superior iliac process of the standing leg to the suprasternal notch.

7. Measure from the suprasternal notch to the ear—*i.e.*, the notch between the tragus and antitragus.

8. Standing at the side, measure between the anterior superior and posterior superior iliac processes on the side of the free leg. Again use the straight-edge, and, holding it horizontally, so that it cuts through the anterior process, note very carefully how much the posterior process comes above this line.

24. Proportions of the Human Frame: Bones
[See opposite page]

1 Skull
2. Breast-bone (sternum)
3. Vertebral column
4. Thorax
5. Collar-bone (clavicle)
6. Shoulder-blade (scapula)
7 Humerus
8. Radius
9. Ulna
10 Wrist-bones (carpus)
11 Metacarpus
12. Finger-bones (phalanges)
13. The haunch-bone (os innominatum)
14. Thigh-bone (femur)
15 Knee-pan (patella)
16. Outer bone of leg (fibula)
17. Inner bone of leg (tibia)
18. Cervical vertebræ, 7 in number
19. Dorsal or thoracic vertebræ, 12 in number
20. Lumbar vertebræ, 5 in number
21. Sacrum, formed by fusion of 5 segments
22. Coccyx, made up of 4 or 5 segments
23. Tarsus
24 Metatarsus
25. Phalanges
26. Os calcis or heel-bone
27. Astragalus
28. Iliac portion of os innominatum
29. Pubic portion of os innominatum
30. Pubic symphysis
31. Head of femur
32 Frontal bones
33. Parietal bones
34. Temporal bones
35. Nasal bones
36. Upper jaw-bones
37 Malar or cheek-bones
38 Mandible or lower jaw
39. Occipital bone
40. Mastoid process of temporal bone
41. Acromion process of scapula
42 Coracoid process of scapula

9. Measure the distance from the suprasternal notch to the seventh cervical vertebra. Use the straight-edge to determine how much higher this is than the top of the sternum.

10. Measure the distance between the posterior superior iliac processes. When doing so great care should be taken in observing, by the aid of a horizontal line, how much higher the process on the side of the standing leg is than the process on the side of the free leg.

11. Measure with the utmost care between the anterior and posterior superior processes on the side of the free leg. If any discrepancy is noticed, take all these pelvic measurements again.

12. Take careful measurement between the posterior superior process of the ilium of the standing leg and the seventh cervical vertebra.

13. Take careful note of the length of the clavicle, measuring from suprasternal notch to the acromion process, on both shoulders.

14. The next measurement should be taken from the acromion process to the head of the ulna on both arms.

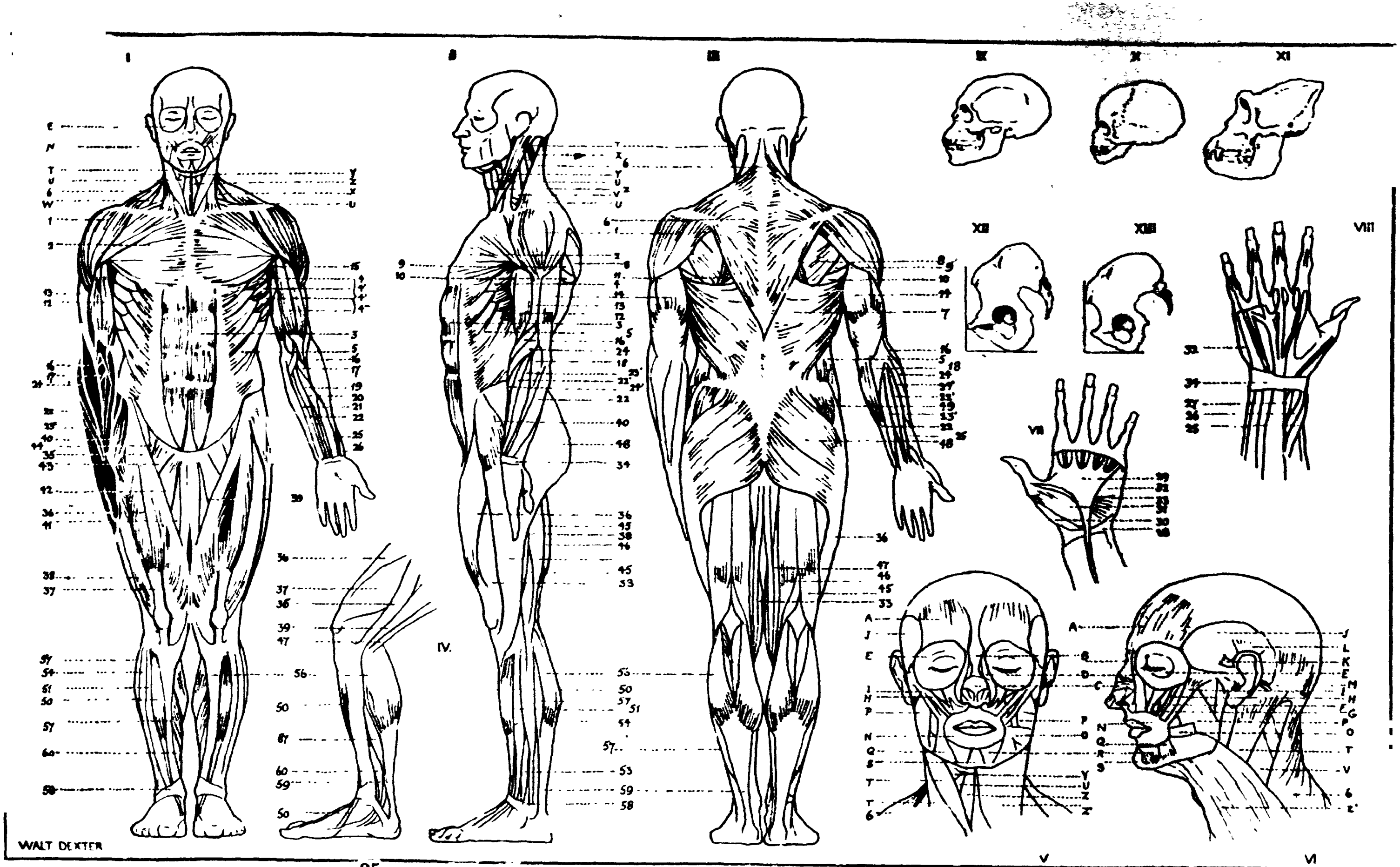
15. From the head of the ulna find the distance to the first articulation of the middle fingers. Mark all these points by wooden matches. These measured points, as the student works, should be carefully checked, as they are liable to be displaced by the putting on of the clay.

Putting on the Clay. In putting on the clay, the student should start by laying in the bone masses. The thorax should come first, and, whatever the pose, it should be equally divided by the vertebral column, so that the mass of the thorax will be equal on both sides. Keep the muscle masses rather under than full size, to prevent obliterating the drawing. Put on the clay in strips and lumps, following the direction and movement of the muscles that are being indicated. Always leave the bone surfaces, which have been marked with matches, bare, but the matches should, of course, be pushed in so that the ends represent the point on the surface from which the measurements have been taken.

The student should always have before him the shapes of the bones over which the muscles are laid. Draw the shape of the thorax carefully from the sides and back as well as from the front. To do this one must have a thorough knowledge of anatomy [see PHYSIOLOGY, pp. 97–101, 196–198], or it will be impossible to interpret the forms which, given this knowledge, will reveal the shape of the underlying construction. The bone surfaces are most important, as they form, as a rule, the great points of rest between large masses of muscle, and give the trunk and limbs their characteristic contour. Observe, for instance, the important part which the humerus and the ulna play in determining the shape of the arm [**26**], and note the extent to which the femur and the tibia decide the character of the leg [**27**]. Again, examine the pelvic girdle and see how the iliac crests influence the shape of that region. If one looks at the shoulder girdle from above, it will be seen at once how the clavicles sweep in a convex line backward and outward, and take a concave line before they reach their articulation with the acromion. This line plays an important part in determining the shape of the great pectoral mass below it, and forms the point of rest between this mass and the muscles of the neck and shoulders. It is utterly useless to rely upon measurements between points which are not absolutely fixed. The student should depend upon his eye in such cases. Measurements cannot determine the pose, but they are used to ensure accuracy of construction.

Anatomical Models. It will be a valuable help to the study of muscle forms if the student provide himself with an anatomical figure. He will then more easily understand the modifications of the surface forms and trace their origin. These figures will not, of course, explain all the subtle movements of the surface form, but by reference to them the student will be reminded of the muscular and bony forms which underlie the surface, and which, when called into action, modify its contour [**24** and **25**].

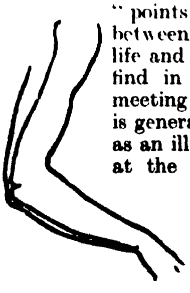
It is desirable to lay in the whole figure together, blocking in the extremities with the



25. PROPORTIONS OF THE HUMAN FRAME: MUSCLES. [See opposite page]
I., II., III., Superficial muscles in male; IV., in leg; V., VI., in head and face; VII., palmar, and VIII., dorsal muscles. Skulls of negro (IX.), infant (X.), gorilla (XI.); XII., male, and XIII., female pelvis

rest of the figure. Having arrived at the arms and hands, the armature for the fingers should be made, for which purpose thin wire is best—copper for preference. Take five lengths of about 5 in. each, and, having bound them securely together at one end, insert this end into the compo tube at the wrist, pushing it up, and then pinching the tubing with pliers, so that a good hold is obtained. The wire is then cut to the required lengths to support the fingers, and is easily bent to the required form.

In modelling the figure in the round, the success of the study depends to a great extent on the groundwork. It is necessary, therefore, that the utmost care be taken in placing the large masses and observing their relative positions. The figure should be constantly turned, so that these masses may be observed in profile and their projection and outline studied with due regard to the general lines of the whole figure. Compare the lines made by the chest, abdomen, and standing leg and the general line of the neck and back. Note also, from the profile, how the line of the back, from the neck downwards, is traceable across the figure, following the iliac crest and down the front of the thigh of the standing leg. Compare the line of the chest and abdomen with the general posterior line of the leg from the knee downwards. These few suggestions will help the student to find many other points of comparison for himself.



26. ARM SHOWING INFLUENCE OF HUMERUS AND ULNA

25. PROPORTIONS OF THE HUMAN FRAME: MUSCLES

[See opposite page]

The same letters and numerals do duty in all figures

A	Occipito frontalis
B	Pyramidalis nasi
C	Compressor naris
D	Levator labii superioris alæque nasi
E	Orbicularis palpebrarum
F	Levator labii superioris
G	Levator anguli oris
H	Zygomaticus minor
I	Zygomaticus major
J	Temporal fascia
K	Attrahens auris
L	Attolens auris
M	Retrahens auris
N	Orbicularis oris
O	Risorius
P	Masseter
Q	Depressor anguli oris
R	Depressor labii inferioris
S	Levator menti
T	Sterno-cleido-mastoideus
U.	Omo-hyoid
V	Scalene
W	Levator anguli scapuli
X	Splenius
Y	Thyro-hyoid
Z	Sterno-hyoid
Z'.	Platysma
1	Deltoid
2.	Pectoralis major
3	Rectus abdominis
4	Serratus magnus
5	Obliquus externus
6	Trapezius
7	Latissimus dorsi
8.	Infra spinatus
9.	Teres minor
10	Teres major
11	Rhomboideus
12.	Biceps
13.	Brachialis anticus
14.	Triceps
15.	Coraco brachialis
16.	Supinator longus
17.	Pronator radii teres
18	Anconeus
19	Flexor carpi radialis
20	Palmaris longus
21.	Flexor sublimis digitorum
22	Flexor carpi ulnaris
23	Extensor minimi digiti
23'.	Ex carpi ulnaris
24	Ex carpi radialis longior
24'	Ex carpi radialis brevior
25	Ex ossis metacarpi pollicis
26	Ex primi internodii pollicis
27	Ex secundi internodii pollicis
28	Anterior annular ligament
29	Palmar fascia
30	Opponens pollicis
31	Abductor
32	Abductor minimi digiti
33	Palmaris brevis
34	Post-annular ligament
35	Sartorius
36	Rectus femoris
37	Vastus internus
38	Vastus externus
39	Gracilis
40.	Tensor vaginæ femoris
41.	Adductor magnus
42	Adductor longus
43	Pectineus
44.	Psoas
45	Biceps
46.	Semi tendinosus
47	Semi-membranosus
48.	Gluteus max
49	Gluteus medius
50	Tibialis anticus
51	Extensor longus digitorum
52.	Extensor proprius pollicis
53.	Peroneus tertius
54.	Peroneus longus
55.	Peroneus brevis
56.	Gastrocnemius
57	Psoas
58.	Annular ligament
59.	Tendo Achillis
60.	Flexor longus digitorum

In modelling there is a principle which is to be found in the works of most great masters. This is the observance of what are called "points of rest." These occur, as a rule, between the large masses, to which they add life and springiness. It is almost impossible to find in the human figure two great masses meeting abruptly and forming an angle. There is generally this dividing point of rest. Take, as an illustration, the section through the chest at the level of the nipples. The two great forms of the pectorals do not meet abruptly, but are separated by the point of rest made by the flat form of the sternum. The points of division between the pectorals and the deltoid are also provided with these important rests. And, again, the two great masses of muscles overlying the scapulæ are divided by a point of rest at the vertebral column. If the student searches diligently for these, and observes them in his work, he will avoid a lumpy and dead appearance of the figure, which can only be escaped by following this principle.

The modelled figure should be occasionally anatomised. This is done by drawing upon the finished study, with the help of anatomical plates, the superficial muscles, bones, and faciæ, removing, so to speak, the skin and the subcutaneous fat. The muscles should be traced and modelled with definition. Knowledge thus acquired is more practical and explanatory than anatomy learned solely from books.

27. LEG SHOWING INFLUENCE OF FEMUR

Proportion. It is not advisable, as a rule, to apply any canons of proportion to the modelling of the figure from life. By the adoption of such rules it is difficult to obtain those individual characteristics which distinguish interesting portraiture from the dull and commonplace. More importance should be given to the accurate measurements of each individual model. For the purpose of working from memory, however, the following table, compiled by Prof. Lanteri, will be found useful and reliable:

From the plinth to the top of the patella	Two heads
From the centre of patella to iliac process	
From the pubic line to the top of sternum	

These three proportions are generally equal.

The arm is three heads in length from the acromion to the first articulation of the index finger.

From the acromion to the head of ulna one head and a half.

From the head of the ulna to the first articulation of the index finger one head and a half.

In these measurements the minimum of variation will be observed.

Continued

Group 14
GEOLOGY
7

Continued from page 1[illegible]

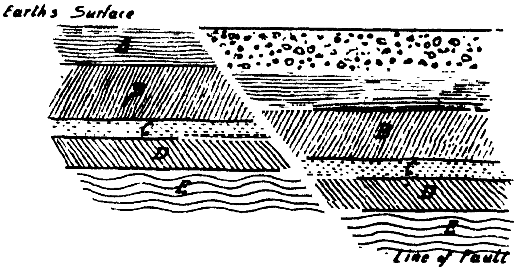
EARTHQUAKE INFLUENCES

How Volcanic Influences have Modified Land Formation and Sea-level. Subterranean Water. The Making of Coal

By W. E. GARRETT FISHER

Earthquakes and the Strata. The geological effects of earthquakes are chiefly of importance beneath the surface of the earth's crust. They give rise to those great breaks of continuity in the stratification of rocks which are known as *faults* [42], and which we shall consider in a later chapter. A fault is a dislocation in the rocks where the strata on one side have been suddenly raised to a higher level than those on the other, and, consequently, they do not appear to be continued in their true order. A seam of coal may thus appear to come to a sudden end, although, as a matter of fact, it can be found again by rising to a higher or descending to a lower level on the other side of the fault. The existence of dislocations of this nature probably indicates that a more or less destructive earthquake once took place at a moment when the rocks could no longer resist the pressure brought upon them by the upper strata, and gave way. Sometimes, also, an earthquake gives rise to a permanent change of level in the surface of the country; this is especially of importance near the sea-coast. By very severe earthquakes it occasionally happens that a long line of shore may be raised three or four feet above its previous level. New land is thus won from the sea, or, on the other hand, many square miles may be submerged beneath the surface of the water.

Secular Movements. We are accustomed to think that an alteration in the level of the land is always due to some violent agency like that of an earthquake. But although such sudden changes are more picturesque and striking than those which go on silently and almost imperceptibly throughout the ages, it is to the latter that the changes in the conformation of the earth's surface are mainly due. The utmost that an earthquake can accomplish is to open a chasm in the ground, such as that which was filled up by the fabled devotion of the Roman hero, or that which more authentic history tells us to have been caused by the earthquake in the Neo Valley, in Japan, in 1891. But the silent forces which are ever at work, raising the sea-bed here, and lowering a whole continent there, are of far greater importance to the student of geology. If it were not for them, indeed, the whole surface of the earth would ultimately become a dead level, and perhaps be sunk beneath an inundation, in comparison with which that which Noah survived was a deluge of inconsiderable magnitude. The denuding forces which, as we shall see in the next section, are constantly at work planing down and polishing off the surfaces of the land would in the long course of geological time, infallibly produce this result were they not counteracted by the slow movements of *upheaval* and *subsidence.*



42. FAULT, OR DISLOCATION

Upheaval and Subsidence. There are countless evidences on every hand to show that an actual rise and fall of the earth's surface does take place. We think commonly of the sea as fluctuating, rising and falling, overflowing the land, and again returning and leaving its beaches high and dry. But the truth is that the sea, though unstable as water, is really a permanent and unchanging thing in comparison to the solid land. Looking at the history of the world with the trained eyes of the geologist, which are able to peer through the backward ages and read the story written on the rocks, we may indeed say with the great poet of our own day:

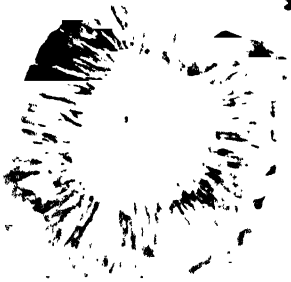
> There rolls the deep where stood the tree;
> O Earth, what changes hast thou seen!
> There where the long street roars hath been
> The stillness of the central sea.
>
> The hills are shadows, and they flow
> From form to form, and nothing stands;
> They melt like mists, the solid lands;
> Like clouds they shape themselves and go.

In these beautiful lines Tennyson has expressed a far-reaching geological fact. The sea and land have changed places again and again in the history of the earth.

When we speak of the secular rise and fall of the sea, as distinguished from the periodical tidal changes, what we really mean is that not the sea but the land itself has sunk below or risen above its average level. There are two ways, and only two, in which the permanent level of the sea may be changed—for an actual diminution of the actual bulk of its waters is not known to have occurred within historical times, and its probability may be left out of account. The land which borders the sea may be slowly raised, thus bringing more and more of the sloping beach out of the water; or the sea-bed

Corundum (Aluminium oxide)
[illegible] (p. 768)

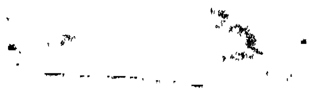
Crystal of Selenite, or Gypsum (Sulphate of calcium)



Iron Pyrites (Sulphide of iron)
Commonly called [illegible]
(p. 768)

Aragonite (Calcium carbonate)
(p. 768)

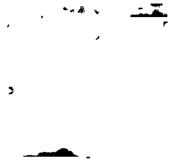
Fibrous Gypsum
(p. 768)



Quartz Crystal (Silica)
Amethyst coloured by manganese

Native Sulphur
Showing crystalline structure
(p. 767)

Quartz Crystals



Smoky Quartz Crystal
From St. Gotthard (p. 767)

A SECOND GROUP OF TYPICAL MINERALS

Reproduced by Photography and coloured from Nature

[illegible]

may sink, which obviously has the same effect, in causing the sea to retreat from the land. On the other hand, if the dry land subsides, or if the sea-bed is raised, it is clear that in either case the result will be the same—an apparent rise in the level of the sea.

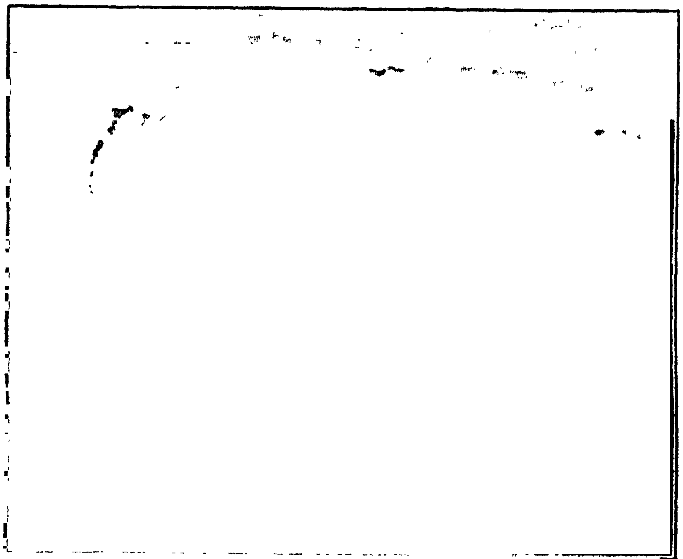
Changes in the Sea-level. There is visible to the most casual observer a great deal of evidence that the level of the sea has thus been actually changed during comparatively recent times. In the first place we have the fact that the remains of organisms which can only live in sea-water are found as fossils in rocks which are at present high above the level of the sea. Thus in Cuba a coral reef has been found at a height of more than 1,000 ft. above the sea-level, which clearly shows that the land has there been elevated to at least that extent. A very striking instance is afforded by the pillars of a Roman temple in the Bay of Naples. When these pillars were erected, 2,000 years ago, they stood, of course, on dry land. They stand on dry land now, but they are traversed by holes which were evidently burrowed by marine creatures at a time when they were covered by the sea to a depth of at least 20 ft. Thus it is evident that since the beginning of the Christian era the land at that particular spot has first sunk and then risen several yards.

By permission of *Mr. W. Lamond Howie*

43. PARALLEL ROADS OF GLEN ROY

Puzzling Fossils. One of the problems which did most to perplex the early geologists was the occurrence of shells at considerable heights above the sea-level. The most grotesque hypotheses were put forward to account for this. Some held that the shells had been deposited there by pilgrims who used to wear scallop shells in honour of the saints whom they visited; others held that these shells represented the haunts of the primeval oyster-eater; others took refuge in the supposition that the shells were not really shells at all, but were *lusus naturæ*, or freaks with which Nature amused herself by imitating the products of the sea. We know now that wherever we find fossils of this kind they are simply a proof that the rock in which they occur at one time formed part of an ancient sea-bed.

Raised Beaches. Another very interesting proof of the gradual elevation of the land is given by what are known as raised beaches. The sea-beach, or the space between the extremes of high and low water, is a very familiar and recognisable structure. It consists, as a rule, of sand, or gravel, with which are mingled shells and other remains of marine organisms. In many parts of the country these unmistakable platforms are nowadays



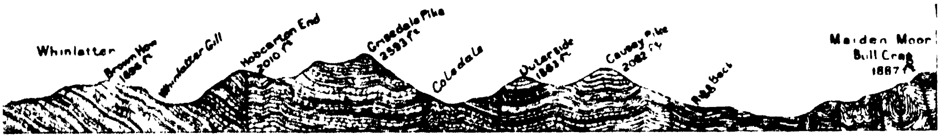
By permission of *Mr. W. Lamond Howie*

44. PARALLEL ROADS OF GLEN ROY (Near View)

found raised high above the level of the sea. In many parts of Scotland, and on both sides of the English Channel, these raised beaches are to be seen. Alten Fjord, in Norway, is surrounded by a series of raised beaches—four or five terraces divided by intervals of many feet, which mark successive levels of the sea during quiescent intervals in the motion of the land, which, on the whole, has been steadily rising.

The so-called parallel roads of Glen Roy [**43** and **44**] are similar lacustrine beaches, which, however, owe their existence to an actual subsidence of the waters which formed them. As one gazes southward from the top of Reigate Hill over the district known as the Weald, i is easy to suppose that one is looking from the top of an ancient sea cliff across what was formerly an arm of the English Channel, but which the gradual rising of the land has claimed for the work of human cultivation.

Where the Land has Sunk. Proofs that the land has sunk in some places as well as risen in others are not wanting. We do not refer to the mere eating away of the land margins by the sea, such as is constantly occurring on the east coast of this country—this is due to erosion simply, and is dealt with in a subsequent chapter—but there are many places in which the remains of primeval forests are found submerged beneath the sea. The existence of submarine coal-mines, such as are found off the east coast of Scotland, where the workings frequently extend far out beneath the sea, shows that the waters now roll over spots which were long ago covered with terrestrial vegetation.



45. SECTION BETWEEN WHINLATTER AND MAIDEN MOOR, NEAR KESWICK, SHOWING WRINKLING
Black lines represent faults

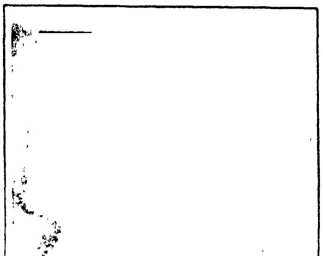
Not infrequently, in boring through the crust of the earth, the remains of ancient forests are found, overlaid with deposits of sand and mud, and mingled with the fossil remains of marine organisms which were evidently deposited by the sea. In making a new dock at Barry, on the Bristol Channel, clear proof was shown that the sea-level there had risen, or, in other words, the land had sunk, by more than 50 ft. The existence of coral reefs [see page 558] is asserted to afford another proof of the gradual subsidence of the land. The reef-building coral cannot live at a greater depth than about 150 ft. Yet in many cases the reefs which they build are found to rise out of water very much deeper than they could possibly inhabit, so far as we know. The obvious explanation of this fact is that the reef builders began their work when the depth of water at this spot was not greater than 150 ft. As they build upwards towards the surface, the sea-bed which served them as a base is supposed to be slowly subsiding, so that their unwearied labour is devoted to keeping their reef built up to the level of the sea. Some doubt has been thrown upon the universally satisfactory character of this explanation, which we owe to Charles Darwin ; but it is practically certain that, in some cases, at least, the existence of coral reefs rising as sheer pinnacles out of the deep water of the Pacific can only be explained by the gradual subsidence of the sea bottom.

Living Proofs of Land Movements. Other proofs of the gradual subsidence of the land are derived from the distribution of living plants and animals. Thus, it is fairly obvious that our own island must at one time have been joined by a strip of land to the continent of Europe, since no particular difference is found in either flora or fauna as we cross the Channel, which, indeed, is only of geologically modern origin. Its existence is solely due to the sinking of the land and the consequent invasion of the sea. Again, the Norwegian fjords and many of the Scottish and Irish Sea lochs present all the characteristics of river valleys, or glens, which the sea only entered long after they had been carved out by the running streams. In other words, the coast-lines on which such fjords and lochs occur have subsided since their formation. In many cases, also, the history of mankind, brief and almost evanescent though it is in comparison with the awful length of the great geological record, affords proof of the subsidence of coast-lines. On the coast of Sweden, Dalmatia, and Japan—indeed, on almost all civilised shores—ancient buildings are now found below high-water mark.

Unconformities. In not a few instances the study of the layers, or beds, in which the stratified rocks are arranged shows that elevation or subsidence of the land has taken place. We find, for example, that ancient beds, laid down by deposit from the sea in roughly horizontal planes, have thereafter been folded or contorted by movements of the crust [**45**], which will be explained later. In later ages, these folds, or contortions, have again been worn down by the erosion due to terrestrial agencies, until a comparatively flat surface has been left, and upon this flat surface fresh marine deposits have again been laid in horizontal planes, beneath which the older strata are found lying at many different angles. Where this phenomenon occurs it is known as an *unconformity*, and its existence invariably shows that the land has once formed part of an ancient sea bottom, has then been raised above the sea-level, and subjected to atmospherical and similar agencies of denudation, and has then once more been submerged beneath the sea and covered by the deposit of fresh layers.

Cause of Secular Earth Movements. Having convinced ourselves that the land does actually rise and fall through long ages, it remains to inquire why this should be the case. A little thought will enable us to reach a plausible answer, which has the further merit of being exactly true. If the earth were a solid body throughout, and uniform in temperature, there would be no reason why any part of its surface should change its position with regard to the rest. The agencies of denudation would be allowed to work their way with unchecked dominion, and the whole earth would ultimately be reduced to one dead level, which the waters of the ocean would cover to a depth which was practically the same throughout. But, fortunately for us, the earth is still alive. The fiery legacy of the nebula from which it was cooled is still potent to preserve it from this threatening fate. The earth is still cooling, and in accordance with the law which affects practically all cooling bodies, as it loses heat it shrinks or contracts. But the rate of this contraction is not uniform. The outer layers of the crust remain, and have long remained, at a constant temperature; consequently, it is the inner portion, or heated nucleus, of the earth which continues to shrink, while the solid crust remains firm.

The Earth in Wrinkles. The result of this process is exactly the same as that which produces wrinkles on the skin of a withered apple [46] or on the face of an elderly woman. The central substance, as it shrinks, leaves the rind, or skin, or crust behind, and the latter, which sooner or later lacks the strength to hold its early form, is obliged to adapt itself to circumstances. This it does in the case of the human face or the apple by wrinkling into folds; and exactly the same thing takes place in the crust of the earth. The mountain chains and valleys, which form a prominent feature of the earth's surface, were all caused in the first instance by the gradual folding of the earth's crust as it settled down upon the shrinking core. This process is still going forward, though, of course, at a much slower pace, and with much less marked effects than in the early days of the earth when the Alps and Andes and Himalayas were formed. It is this process of crumpling, or folding, in the earth's crust which is able to account for the greater part of the upheavals and subsidences which the surface of the earth is known to have undergone. It might seem that the contraction of the earth is only competent to account for subsidence; but a moment's thought will show that such a process of wrinkling, or distortion, as we have described will give rise to subsidence in one place, and to upheaval in another.



47. SLATE FROM PENRHYN, SHOWING PLANE OF CLEAVAGE

Further, other and secondary causes, closely allied to the secular cooling of the earth, have been invoked to account for the local rising or falling of the land. If, for instance, a portion of the underlying crust be exceptionally heated by the intrusion of molten rock from below, as no doubt happens at the birth of a new volcano, it is reasonable to suppose that the explosion due to this heating may elevate a considerable tract of land on the surface. Conversely, the contraction of a subterranean lake of molten lava, as it cools and hardens, may cause the ground immediately above it to subside—much as on a smaller scale we know that the ground often subsides over the working of mines, or the hollow strata from which salt has been pumped out in the form of brine. We are still very far from forming a clear and perfectly scientific idea of what actually goes on in the lower regions of the earth's crust. But there can be very little doubt that the secular movements of the earth's crust, whether of elevation or of subsidence, are intimately connected with the cooling and consequent shrinkage of the earth's heated interior.

46. APPLE WRINKLED BY WITHERING

Chemical Action Underground. The last form of hypogene action which we have to consider is that which brings about actual changes in the character or composition of the rocks in the great subterranean laboratory where they were originally formed. The effects thus produced are mainly due to one or more of three causes—heat, pressure, and solution. As a rule, more than one of these causes operates at the same time. A rock may be influenced by heat and pressure and the action of water all at the same time, or by any two of them. Thus, it may be pointed out that marble, which is a crystalline limestone, is due to the heating of the ordinary calcareous rocks under pressure. If limestone be fiercely heated on the surface of the earth, we know that we shall succeed only in driving off its carbonic acid gas, and leaving quicklime; but experiment has shown that if it be heated under great pressure, the limestone, instead of losing its carbonic acid gas, actually melts, and if it be allowed to cool slowly, it crystallises into marble. Under the pressure of strata, many thousands of feet in thickness, it is easy to see that the high temperatures existing at such depths as these may have turned limestone into the existing deposits of marble. Again, the heat of the lower regions of the crust, or of vast intrusive masses of lava welling up towards the surface, may exercise a baking and hardening effect upon the sedimentary rock with which they come in contact.

Subterranean Water. The solvent power of water upon rocks is accordingly increased when the water is heated or contains various chemical agents, as is undoubtedly the case in the lower regions of the earth's crust. Thus, in certain cases great changes are produced in the structure of rocks by the removal of some of their original constituents, through solution in water, which carries them away, or by the deposit of other substances which the water had dissolved and brought from another part of the crust, or by an actual chemical change in the minerals composing these rocks. The remarkable snake-like rock known as serpentine has thus been produced from the original olivine. Limestone, which is very soluble in water, especially in the presence of carbonic acid gas, is often found to have been replaced entirely by another mineral, such as silica, which betrays its origin by assuming the typical crystalline form of the original rock, like what in popular language is called a petrification.

Effects of Underground Pressure. The effect of the pressure of overlying strata upon rocks at great depths beneath the crust may be very considerable. It may roughly be considered that the pressure thus exerted upon a rock is about 1 ton to the square inch for every 1,500 feet of superincumbent strata. It is difficult to realise what far-reaching and tremendous effects such a pressure as exists at a depth of 100 miles must have upon the rocks. The strata at these depths are ruptured and dislocated, or consolidated into extraordinarily compact masses. The effect of pressure which we have specially to notice here is to produce the phenomena known as *cleavage*. It has been found by experiment that such a substance as beeswax, when subjected to a severe pressure, develops "cleavage planes," along which it can readily be split into a series of thin plates. Many rocks are found to have developed similar cleavage planes under the severe pressure which they have undergone at a depth of some miles beneath the surface of the earth. Slates, which owe their commercial value to the readiness with which they can be split into thin plates along their cleavage planes [47], afford an excellent instance. Originally, they consisted of hardened clay, which no doubt presented the ordinary strata, or bedding planes, which characterise all sedimentary rocks. The cleavage planes which have been induced by pressure have superseded these planes in the altered strata, and, as a rule, run in quite a different direction from them, showing that they have been produced by pressure acting at the ends of the planes of stratification and at right angles to them. The phenomena of cleavage are largely due to a molecular rearrangement of the minute particles of the rock, which all tend to turn their longer axes perpendicular to the direction of pressure, much as may be observed with dates or raisins which have been pressed into a solid lump. The fossils which are sometimes found in rocks which have undergone cleavage confirm this view by showing that they have been greatly distorted from their original shape.

Making of Coal. One of the most important processes carried out in the great subterranean laboratory, from a human point of view, is the conversion of vegetable substance into coal. This takes place, as a rule, when the vegetable substance is exposed to the action of water at a temperature and under a pressure considerably greater than those which obtain at the surface. Under these conditions, the gases are gradually driven off from the vegetable matter, and the proportion of carbon thus increases until, after passing through the various stages of peat, lignite, and bituminous coal, it ultimately reaches the condition of anthracite, or even of graphite, which is practically pure carbon.

It should here be added that subterranean water frequently contains minerals which serve as a cement for the loose grains of sand or gravel through which it percolates. Carbonate of lime, silica, and some iron oxides are the principal components of these cements, to which a large number of rocks of sedimentary origin now owe their consistency. Conglomerate, or pudding-stone, breccia, and various sandstones, afford instances of this.

Continued

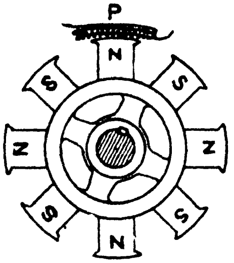
Continued from
page 1328

THE ALTERNATOR

Properties of Alternating Currents. Alternators. Armatures and Magnet-wheels. Questions of Lag and of Phase

By Professor SILVANUS P. THOMPSON

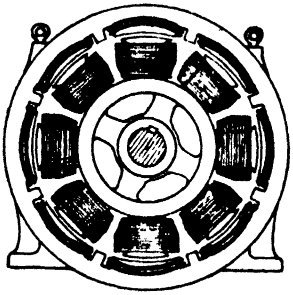
Alternating Currents. Electric currents supplied from a battery are described as *continuous* currents because they flow continuously in one direction around the circuit. But there is another kind of electric current, which has the property that, instead of flowing, in one direction along the conducting wire, it is continually flowing backward and forward in rapid alternations of directions. Such currents might be called oscillatory or undulatory; but the accepted name for them is *alternating currents*. They are much used for long-distance transmission work. A part of the City of London is supplied with electric energy from a generating-station at Bow, five miles away. The current is at one instant flowing between Bow and London; at the next instant it stops, and then reverses in its direction; then stops, and reverses again, and flows in the original direction, and so on in rapid succession, reversing actually 100 times a second. Two such reversals constitute one *cycle*, and the time occupied by one cycle is called one *period*. So that in this case there is a *frequency* of 50 cycles per second, or the *period* of the current is $\frac{1}{50}$ of a second. Frequencies of 100 cycles per second were formerly used for electric lighting, but a frequency of 50 is now preferred; while for special power-plant (as at Niagara) the lower frequency of 25 cycles per second is adopted.



77. MAGNET-WHEEL, 8-POLE

Alternating Voltage. In order to cause the current to rush forwards and backwards 50 times a second it is clear that the electromotive force which is applied to generate the current must itself be alternating with the same frequency—in each second there must be 100 electromotive impulses, 50 of them tending to drive the current forward, and 50 of them tending to drive it back. How shall this be accomplished with so great a rapidity? How can the revolutions of a steam-engine set up such rapid alternations?

Alternating Induction. On page 949, on the discoveries of Faraday, we described the inductive effect of plunging the pole of a magnet into a coil of wire. It was pointed out that when the pole is plunged in there is a current induced in the coil, and that when the pole is pulled out there is a reverse current induced in the coil. It is clear that if we could push in and pull out that pole 50 times a second we should generate alternating currents having a corresponding frequency. But it is not necessary that the magnet-pole should enter the coil. As pointed out in that chapter, all that is necessary is that there should be *relative movement* of the conducting copper wire and the magnet-pole, so that the magnetic lines of the pole shall be "cut" by the copper conductors. Consider, then, how we might design a machine to be driven by a steam-engine that would give us this rapid alternating induction of voltage. Suppose a number of electromagnets to be fixed upon the rim of a steel wheel, with their poles pointing outwards, as in 77, and so arranged that these poles shall be alternately north poles and south poles. Then let a coil (P) of insulated wire be wound upon a suitable core (built up of iron plates) and fixed opposite one of the magnet-poles. (It is assumed that the electromagnets fixed on the wheel can be kept magnetised, as described hereafter.) Then, if the magnet-wheel is revolved, as its poles fly past the fixed coil there will be induced in the coil a succession of electromotive impulses that tend to set up alternating currents. For while a north pole is coming up, the induction will act one way round the coil, and while the north pole is retreating and a south pole is coming up, the induction will act the other way round the circuit.



78. ALTERNATOR, 8-POLE

Frequency and Number of Poles. Fig. 77 represents the magnet-wheel as having eight poles—that is, four norths and four souths. In one revolution it will, therefore, induce eight alternations or four complete cycles. If a frequency of 50 cycles per second is wanted, the wheel must be driven at a speed of 12½ revolutions per second or 750 revolutions per minute. If the wheel had had only four poles it would have needed to be driven at 1,500 revolutions per minute to give the standard frequency of 50 cycles per second. If we were compelled to use a slow-speed steam-engine making only 150 revolutions per minute, the magnet-wheel would require 40 poles. The following table shows the relation.

ENGINE-SPEEDS FOR A FREQUENCY OF 50 CYCLES PER SECOND

No. of Poles.	Cycles per Rev.	Revs. per Sec.	Revs. per Min.
2	1	50	3,000
4	2	25	1,500
6	3	16⅔	1,000
8	4	12½	750
10	5	10	600
12	6	8⅓	500
20	10	5	300
30	15	3⅓	200
40	20	2½	150
60	30	1⅔	100

Such high speeds as 1,000 revolutions per minute or more are suitable only for steam-turbine driving. The frequency (f) can be calculated from the revolutions per minute by dividing the latter by 60 and then multiplying by the number of *pairs* of poles. Thus, a 10-pole machine running at 720 revolutions per minute will give a frequency of 60 cycles per second.

Armatures for Alternating Generators. When it is desired to generate high voltages, not only must the magnet-poles be such as to furnish an adequate flux of magnetic lines, but there must be a sufficiently large number of turns of copper wire in the coils that are to be acted on inductively by the revolving poles. In **77**, only one coil is shown. But if, as in **78**, there are provided as many coils as there are poles, and if the coils are so spaced out that at the instant when one of them is opposite a pole all the others are also opposite the respective poles, then they will all work together, and may be connected up into series as one winding. Such a group of connected coils, together with the laminated iron cores on which they are wound, and the frame in which they are held, will be called the *armature* of the machine. As it usually stands still, such an armature is also called a *stator*. The coils must be so joined up that the currents circulate.

Alternators. The entire machine, consisting of field-magnet and armature, is called an *alternating current generator*, or *alternator*. We have seen that it may be regarded as evolved from Faraday's original apparatus. It is made in many sizes, from the little *magneto ringers* used in telephone work for ringing the calling-up bells to huge generators 20 or 30 feet in diameter, requiring thousands of horse-power to drive them.

It is easy to calculate out from the constructive data of a machine, and the speed at which it is driven, the voltage at which it works; for the voltage it generates is proportional to its speed, to the number of its poles, to the number of coils in series on its armature, and to the flux of magnetism in any of its poles. The formula by which to calculate the voltage is

$$E = k \times f \times S \times N \div 10^8$$

where N is the number of lines in the flux from any one pole, S the number of spirals or turns in series with one another in any circuit of the armature, f the frequency, k a coefficient depending on the shape of poles and distribution of the windings (k is usually of the value 2·2), E the voltage of the alternator, and 10^8 is the numerical factor to reduce to volts, because, as explained on page 1324, to create one volt there must be 100,000,000 magnetic lines cut per second.

79. TWO-PHASE, "A" TYPE, 30-POLE ARMATURE

As an example, suppose this 8-pole alternator [**78**] to run at 750 revolutions per minute, and to have 36 turns on each of the eight armature coils, and $3\frac{1}{2}$ millions of lines as its pole-flux. As each of the eight coils has 36 turns, S will equal 288. If it run at 750 revolutions per minute, this is $12\frac{1}{2}$ revolutions per second, and with four pairs of poles in the circumference the frequency will obviously be 50 cycles per second. Then, taking $k = 2{\cdot}2$, we have:

$$E = 2{\cdot}2 \times 50 \times 288 \times 3{,}500{,}000 \div 100{,}000{,}000,$$

or, working the arithmetic,

$$E = 1{,}108 \text{ volts.}$$

Types of Alternators. There are three leading types of alternators—namely, (A) small machines, having stationary field-magnets, resembling the field-magnets of multipolar dynamos, and with revolving armatures; (B) large machines, with revolving magnet-wheels (as in **78**) and stationary armatures; (C) high-speed machines, for steam-turbine driving, having external stationary armatures and internally revolving field-magnet systems of peculiar construction. There is yet another type, not much seen now, in which the armature stands still, and the magnetising coils of the field-magnet also stand still, the only thing that revolves being masses of iron fastened to a shaft, and which, being magnetised, act inductively. These are called *inductor alternators*.

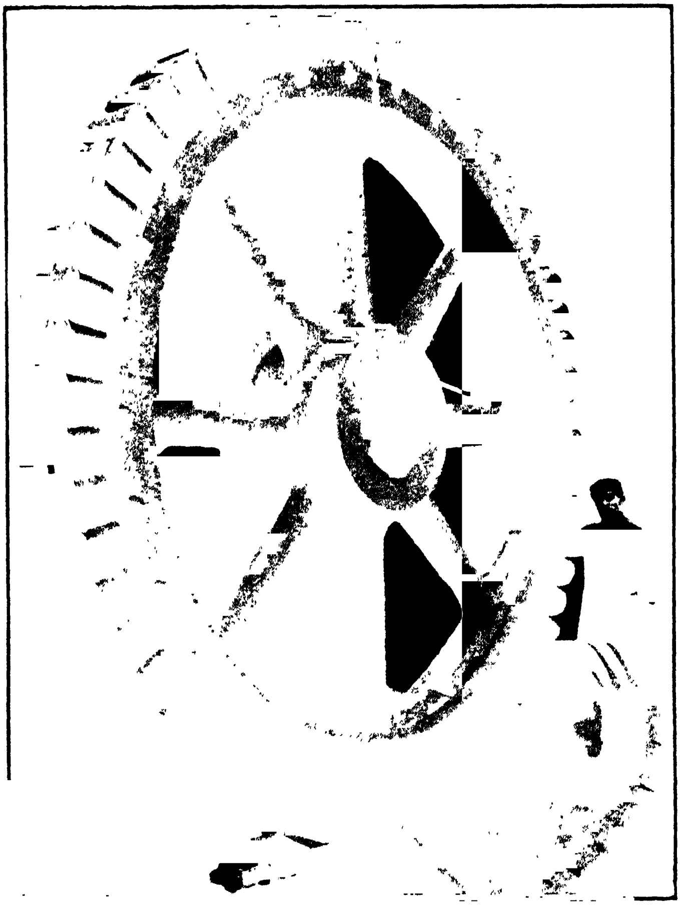
Alternators of the A type, with revolving armatures, require sliding contacts to connect the revolving coils to the external circuit. These sliding contacts are made by connecting the ends of the armature winding to insulated metal rings (known as *slip-rings*) fixed on the shaft. Against these metal rings press collecting brushes of metal or carbon. Any single-circuit alternator of this type will require two such slip-rings. But there are machines with three circuits, called three-phase alternators, which require three slip-rings, and two-phase alternators with four slip-rings, as **79**. Owing to the difficulty of satisfactory insulation of revolving windings, if high voltages are required it is much preferable to employ machines of the B type, with stationary armatures.

Revolving Magnet-wheels. As we have seen, these structures present a set of radiating poles. The pole-cores are sometimes of solid steel, sometimes built up of steel stampings, but, in any case, they must be stoutly secured by dovetails or by bolts to the rim of the foundation wheel; and this is often made of immense thickness to serve also as a fly-wheel.

Fig. **80** shows such a magnet-wheel separately To magnetise the poles, the projecting iron cores are wound with massive coils, usually composed of copper strip about 1 in. broad and $\frac{1}{10}$ in. thick, wound edge-wise. The magnetising current must be brought from a continuous current machine, called an *exciter*; and, as it must be brought to the revolving structure, sliding contacts are necessary, two slip-rings being fixed on the shaft to receive the exciting current from the contact-brushes and to convey it to the magnetising windings. These slip-rings are seen in **80** ready to be fixed upon the shaft.

A smaller magnet-wheel with eight poles is shown in **81**; it has the slip-rings attached, and shows their connection to the exciting coils on the poles.

Stationary Armatures. The stationary armatures of large slow-speed alternators are well illustrated by **82**, which represents an armature just completed in the factory. The *core-body* is a great ring built up of thin stampings of soft steel or iron, fixed in a strong cast-iron *housing*. The coils, previously shaped on wooden formers, are inserted in slots in the peripheral face of the core, and are fixed in with wooden wedges. When the magnet-wheel is in its place, and revolving, the magnetic fluxes from its poles sweep past these coils and induce electromotive forces in them. One of the largest of such machines yet made is of 8,000-horse power, running at 75 revolutions per minute, in the Manhattan station at New York. It is about 30 ft. in diameter. But smaller machines of greater power for driving with steam turbines at high speeds have been built. These will be described in a later article.



80 SIXTY-POLE MAGNET-WHEEL OF ALTERNATOR. (Dick, Kerr & Co.)

Wave-form of Alternating Impulses. Consider, in detail, how an alternating electromotive force, or an alternating current, varies within one cycle. The impulse begins, it increases in strength up to a maximum, then it dies away to zero, reverses, increases (in the opposite direction) to a negative maximum, and finally dies away to zero, to begin a new cycle. If we divide the period of one cycle into quarters, we see that if the operation is symmetrical the two maxima—positive and negative—will occur at the end of the first and third quarters. To represent such variation in detail, it is usual to depict them graphically in a wave-diagram, such as **83** (*a*), in which the horizontal measurement from left to right represents an ever-increasing time, and the vertical height above or below the level line represents the particular value of the impulse from instant to instant.

Fig. **83** (*a*) represents the impulse as going rather suddenly to its maxima, which are in the form of peaks. The shape of the curve which represents the periodic variations in the induced voltage is called *the wave-form* of the alternator. If the coils of the armature have a span equal to the pole-pitch, and are concentrated in narrow slots in a core of smooth periphery, the wave-form of the alternator will depend only on the shape of the magnet-poles. If these are pointed, the wave-form will be peaky; if they are broad and blunt [**83** (*a*)] the wave-form will be rounded, or rounded with flat tops. Narrow poles generally cause peaky waves. Wide slots in the periphery of the armature core cause distortions that show themselves as ripples on the outline of the wave-form. Thus **83** (*c*) is the wave-form of the alternating voltage supplied to the town of Carlsruhe.

81. REVOLVING MAGNET-WHEEL, 8-POLE, OF SMALL ALTERNATOR, SHOWING THE SLIP-RINGS

Virtual Value of an Alternating Voltage. Suppose an alternating voltage to vary during the period from 0 up to + 200 volts, then back to 0, then to − 200 volts finally back to 0, what will be its working value as a voltage? It will not do to take the mean or average in the ordinary sense, for the average taken from the beginning to the end of the period is clearly zero. Neither will it do to take the average during half a period. Whatever value is the right one, it will be clearly more than 0, and less than 200; it will be something between the greatest and least values. And the value will clearly depend on the question whether the curve rose in a peaky way, or in a round-shouldered way toward its maximum. A clue to the correct answer to the question may be found by inquiring how the instruments used as voltmeters and amperemeters for an alternating supply are constructed. If they are examined, it will be found that they indicate a special kind of mean of their own, which is neither an arithmetical nor a geometrical mean, but is a *quadratic mean*; or, in other words, they indicate the square root of the mean of the squares of all the values. It is impossible in the short space available to go fully into this. But, for example, it may be summarily pointed out that in those amperemeters and voltmeters which work on the principle of the expansion of a hot wire, the heat at every instant imparted to the wire is proportional to the square of the current in the wire; that the inertia, thermal and mechanical, of the instrument averages these squares; and that the dial is so constructed as to read in proportion to the square roots of the mean expansion. It may be remarked that in an alternating hot-wire amperemeter the point on the scale marked "10 amperes" *must* be that point to which the pointer goes when the wire is heated by 10 actual amperes going through it. And if an alternating current is sent through it of such a strength that it also sends the pointer to the same spot—that is, heats the wire to the same extent—such a current is virtually 10 amperes, and ought to be called so, though it will be varying between 0 and 14 amperes or so one way or the other. The value which instruments read is therefore called the *virtual* value; the adjective *virtual* (French *efficace*) meaning the "quadratic mean."

A numerical example will make things plainer. Suppose that a current varies between maxima of 6 and − 6 amperes. What is its virtual value? If **84** represent its wave-form, and if we divide the period into 12 equal parts, we shall find that we may represent the successive values in one cycle as follows:

$$0 + 3 + 5 + 6 + 5 + 3 + 0 - 3 - 5 - 6 - 5 - 3 - 0.$$

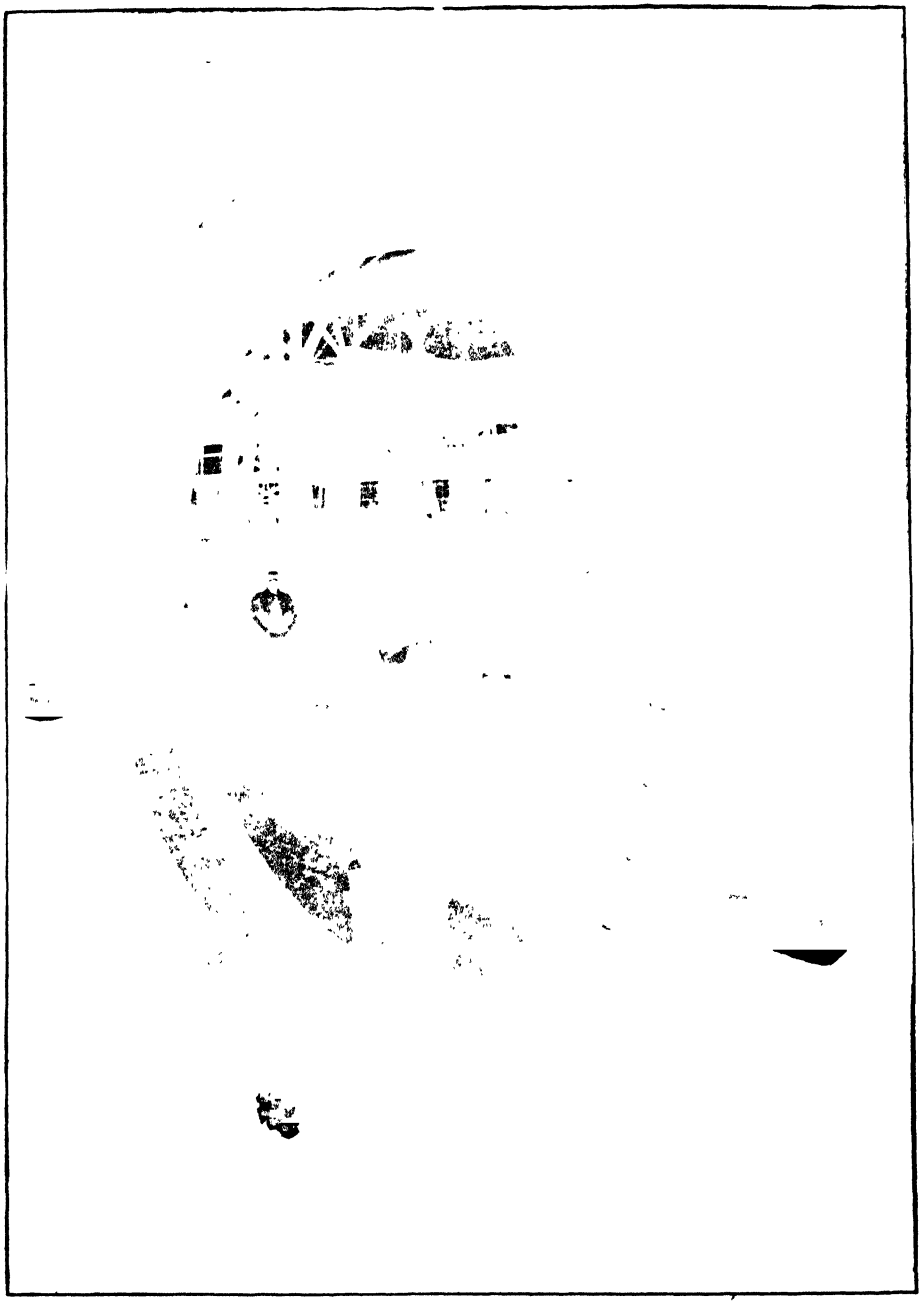
Now write down the squares of these numbers:

$$0 + 9 + 25 + 36 + 25 + 3 + 0 + 9 + 25 + 36 + 25 + 9 + 0.$$

The sum of these squares is 208, and dividing by 12 gives us as the mean 17·33. Take the square root of 17·33 and we get as the quadratic mean, or virtual value, 4·16. That is to say, this is an alternating current of 4·16 *virtual amperes.*

Virtual and Maximum Values for a Smooth Wave-form. Suppose the variations of an alternating voltage or current to follow a *smooth wave-form*—and by this we mean, in mathematical language, that they vary as a sine-function of the time—then the virtual value will be 70·7 per cent. of the maximum, or the maximum will be 141·4 per cent. of the mean. Thus, if a voltmeter *reads* 100 virtual volts, we shall know that the voltage is actually varying between + 141·4 and − 141·4 volts. Or if it read 30 volts, we shall know that the value is really varying between + 42·42 and − 42·42 volts. If the wave-form be not smooth, the maxima will have some other ratio to the virtual value.

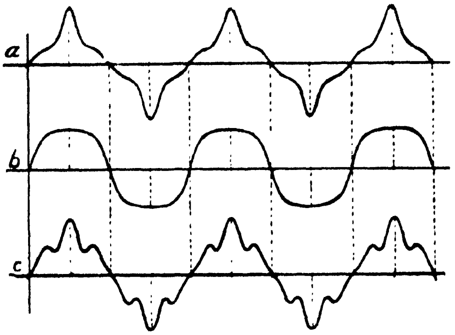
Closely connected with this point is the value of the coefficient *k* that comes in in the design of alternators. If the alternator is so designed that it gives a smooth wave-form, the value of *k* will be 2·22. If it is designed to give a more sloping curve, the value of *k* will be less, or if a



82. STATIONARY ARMATURE OF 40-POLE ALTERNATOR, 2,000-HORSE POWER, UNDER CONSTRUCTION IN THE WORKSHOPS OF MESSRS. DICK, KERR & CO., PRESTON

more high-shouldered curve, the value of k will be greater.

Lag and Lead. Every electric current is an effect of which the voltage applied to the circuit is the cause. If the voltage is an alternating one, it follows that the resulting current will be an alternating current and that it will have the same frequency as the voltage which causes it. But there is this difference: that the resulting alternating current may not follow the alternating voltage in all its details, nor does it always keep in exact step with it. The wave-form of the current may differ from that of the voltage, being modified by reactions due to apparatus in the circuit. This point need not trouble us. But of immense importance is the circumstance that the current will not necessarily keep step with the voltage. For it happens in almost every actual circuit in which alternating currents are used that the current *lags* a little with respect to the voltage. Let us understand what this means and why it occurs.



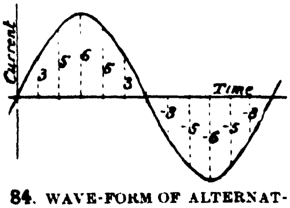
83. WAVE-FORMS OF ALTERNATING VOLTAGES

Fig. 85 depicts two alternating curves, marked V and C. If we look at the length on the time-line we see that the duration of the period of the C curve is the same as that of the V curve ; but they do not begin together, they do not reach their top values together, they do not both die down to zero at the same instant. In fact, the C curve *lags a little* behind the V curve ; and the amount that the C curve is shifted to the right with respect to the V curve marks the amount, in time, that one lags behind the other. This is a typical illustration of the way that the current C habitually lags behind the voltage V. The circumstance under which such a lag of the current occurs is whenever the circuit contains any coils that will magnetise. If any electromagnet, or any coil wound round an iron core, is inserted in the circuit, then the current on its way round the circuit must necessarily do some magnetising. While the current rises, the magnetism must grow ; while the current is dying away, the magnetism must die. This growth and dying of the magnetism in the circuit itself set up self-inductive reactions, with the result that the current cannot grow up as quickly or as soon as it otherwise would do, and cannot decrease or die away as quickly or as soon as it otherwise would die. So it is compelled to lag. In other words, the lag of current is due to the self-induction in the magnetising coils in the circuit ; and the self-induction not only causes the current to lag in time, but it is actually choked in amount : it cannot rise to so high a maximum as it otherwise would attain to if it were governed by the mere resistance of the circuit.

As a matter of fact, there is another case where the current is forced to occur earlier—that is, to *lead* instead of to *lag*. This occurs when a condenser, or anything else having electrostatic capacity, is introduced into the circuit ; but this is not the place to enter on this question.

Difference of Phase. There is another way of regarding this question of lag. The amount by which the current lags behind the voltage is a small fraction of the whole time of one period ; and for certain purposes it is more convenient to think of it as a fraction of the period. No current can be so much retarded by self-induction as to lag as much as one-quarter of the whole period. Now, as the periods of alternation recur in regular succession, like the revolutions of a uniformly revolving wheel, it is found to be a convenient way of describing the amount of a lag to say to how many degrees of an angle it would correspond For example, suppose the frequency to be 50 cycles per second. Then one period lasts $\frac{1}{50}$ of one second. Now suppose the current were caused to lag, say, $\frac{1}{600}$ of a second behind the voltage—that is, $\frac{1}{12}$ of a whole period. If we regard one period as a revolution once round a circle, or 360°, then $\frac{1}{12}$ of this is 30°, and we might describe that current as having a 30° lag. As remarked above, the current can never lag more than 90°, that is $\frac{1}{4}$ period, behind its voltage.

Now, this method of employing the language of angular measurement to describe a lag is convenient for another purpose—namely, to describe any difference of phase that there may be between two alternating currents. Suppose an alternator, such as 77, to be constructed with two independent coils, marked P and Q in 86, each wound in a pair of slots in the armature core ; but let the slots be displaced, so that coil Q is fixed a little further to the right than coil P. Clearly, as the magnet-wheel revolves, it will set up two alternating voltages in these two coils, and if the coils have the same number of turns they will be equal, and certainly of the same frequency. But the voltage in Q will occur a little later than that in P, simply because Q is a little further on. So here we shall have the generation of two equal alternating voltages having a difference of phase between them And this phase difference can be expressed also as an angle. For if Q is displaced from P by

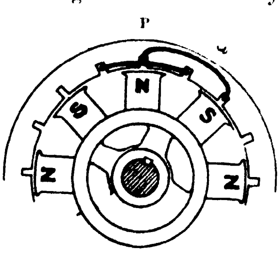


84. WAVE-FORM OF ALTERNATING CURRENT

an amount equal, say, to one-third of the pitch from one north pole to the next north pole, as measured round the periphery of the armature face, then the Q voltage will lag one-third of a whole period behind the P voltage, or there will be a difference of phase of 120° between the P voltage and the Q voltage.

Two-phase. If, as in **86**, the Q coils are displaced exactly one-half of the pole-pitch from the P coils, then the difference of phase between the P voltage and the Q voltage will be one-quarter of a period. Any alternator wound with two independent sets of coils in two phases that are thus one-quarter of a period apart, is called in Europe a *two-phase* machine.

Three-phase. It may be remarked here that one might build an alternator with several different sets of coils, say, a P set, a Q set, and an R set, each displaced beyond the other so as to give rise to three separate voltages that differed successively in phase from one another. The well-known *three-phase* system of currents is nothing more or less than a system of three separate alternating currents which are in this way made to differ from one another in phase by successive angles of 120°. We reserve this system for a future article, the present one not going beyond single-phase working.

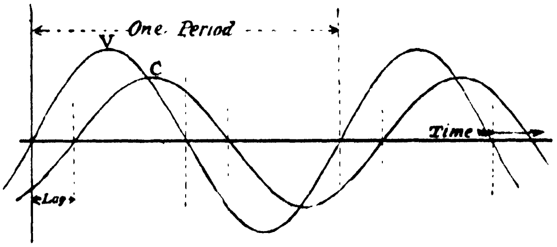


86. ALTERNATOR COILS IN TWO PHASES

Power-factor. Returning to the lag of a current behind its own voltage, we come to a point of vital importance in connection with the *power* of alternators. When a current lags and gets out of phase with its own voltage, then just so far as it gets out of phase it ceases to be effective. For the power [see p. 292] which it conveys is the product of the volts and the amperes only so far as they act together. We come here upon a strict analogy with a most important principle in mechanics—namely, that the work done by a force in producing a movement—usually stated as the simple product (in foot-pounds) of the force into the distance through which the body has moved—is not true unless the force and the resulting movement are in the same line. If the movement is constrained and takes place in some direction at an angle with the force, then the work done is no longer the product of the feet and the pounds; it will be less than that product. The true amount of work can be calculated, as every student of dynamics knows, by multiplying the apparent number of foot-pounds by the *cosine of the angle* [see TRIGONOMETRY, in MATHEMATICS] between the direction of the force and the line of movement. Those who are unfamiliar with trigonometrical terms will find the following simple table useful:

Angle	Cosine of Angle	Power-factor, in Percentages	Sine of Angle	Idle Current, in Percentages
0°	1	100	0	0
5°	0·9962	99·62	0·0872	8·72
10°	0·9848	98·48	0·1737	17·37
15°	0·9659	96·59	0·2588	25·88
20°	0·9397	93·97	0·3420	34·20
25°	0·9063	90·63	0·4226	42·26
30°	0·8660	86·60	0·5000	50·00
35°	0·8190	81·90	0·5736	57·36
40°	0·7660	76·60	0·6428	64·28
45°	0·7071	70·71	0·7071	70·71
50°	0·6428	64·28	0·7660	76·60
55°	0·5736	57·36	0·8190	81·90
60°	0·5000	50·00	0·8660	86·60
65°	0·4226	42·26	0·9063	90·63
70°	0·3420	34·20	0·9397	93·97
75°	0·2588	25·88	0·9659	96·59
80°	0·1737	17·37	0·9848	98·48
85°	0·0872	8·72	0·9962	99·62
90°	0·000	0·00	1·000	100

Thus, if a force equal to the weight of 50 pounds, acting obliquely at an angle of 40° with the line of movement, produces a movement of 6 feet, the number of foot-pounds of work done will not be 300, because only a component of the force is in the line of movement. The true amount is found by multiplying the 300 by the cosine of 40°, namely, 0·766, making the true amount of work done 300 × 0·766 = 229·8 foot-pounds.



85. LAG BETWEEN VOLTAGE AND CURRENT

In the same way, if a current is out of phase with its voltage, the true power in *watts* [see p. 292] will be less than the number of *volt-amperes* of apparent power; and the true *watts* can be calculated by multiplying the *volt-amperes* by the cosine of the angle of lag.

Thus, for example, let a current of 20 (virtual) amperes be sent round a circuit by an electromotive force of 100 (virtual) volts, and suppose that the current lags by 30°, then the apparent power is 2,000 volt-amperes. But since the cosine of 30° is 0·866, the true power is only 1,732 watts.

We may put this into a rule as follows:

True power = volts × amperes × power-factor.

It is for this reason that the cosine of the angle of lag is usually termed the *power-factor*. The usual lags occurring in practice are: For incandescent lighting, 16° to 20°; mixed arc and incandescent lighting, 30°; induction motors, large, 35°; induction motors, small and not well loaded, 55° to 60°; choking coils, 95°; synchronous converters, 0° to 10°.

Idle Component. Wattless Current. So far as the current is out of phase with its voltage, so far it is unable to be productive of useful work or to convey power. To understand this we may again resort to the analogy afforded by the similar case in dynamics. It is a well-known principle that a force does no work, spends no energy, if it acts at right angles to the line of movement. No power or energy is required to deflect a bullet from its path, provided the deflecting force acts always at right angles to that path. The earth exercises an attractive force on the moon to keep it in its orbit, but expends no power or energy on doing so because the direction of the force is in quadrature with the direction of the motion. An oblique force can always be regarded as resolvable into two components, one in line with the motion (this is the working component), the other at right angles to the motion (this is an idle component). So with the alternating current. We may consider it, in fact, as if resolved into two components, one component in phase with the voltage, the other component at right angles (in the sense of 90° of lag) to the voltage. The former is the working component of the current, being the component that possesses the power, and proportional to the cosine of the angle of lag. The latter is the idle component, or wattless component of the current, which conveys no energy because of its being in quadrature with the voltage. It is proportional to the sine of the angle of lag. The two last columns of the table give the corresponding values. If we take as illustration the same case as before of a current of 20 amperes lagging 30° in phase behind its voltage, we see, by reference to the table, that the sine of 30° is 0·5, and, therefore, that there will be 50 per cent. of idle current; that is, though the current is 20 amperes it acts as though 10 amperes were idle or wattless. In fact, the two components into which the current is split up are proportional, one to the sine, the other to the cosine of the angle: the working component is 20 × 0·866 = 17·32 amperes; the idle component is 20 × 0·5 = 10 amperes. If we square each component, add the squares and take the square root, we obtain the value of the whole current: $(10)^2 = 100$; $(17{\cdot}32)^2 = 300$; 100 × 300 = 400; and $\sqrt{400} = 20$, as before. Any purely magnetising current is an idle one, having a power-factor practically zero.

Mean Power of Alternating Current. As the power at any instant is the product of volts and amperes at that instant, we can find the mean power by averaging a set of the instantaneous products. For example, let the current during one cycle have the values:

0 +3 +5 +6 +5 +3 0 −3 −5 −6 −5 −3 0

We have seen above that the virtual value of this current will be 4·16 amperes. Now suppose the voltage to vary between maxima of +20 and −20 volts in the following cycle, the virtual value being 14·1:

0 +10 +17 +20 +17 +10 0 −10 −17 −20 −17 −10 0

Write them down one below the other, and put the products at each instant underneath, thus:

C	0	+ 3	+ 5	+ 6	+ 5	+ 3	0	− 3	− 5	− 6	− 5	− 3	0
V	0	+ 10	+ 17	+ 20	+ 17	+ 10	0	− 10	− 17	− 20	− 17	− 10	0
C × V	0	+ 30	+ 85	+ 120	+ 85	+ 30	0	+ 30	+ 85	+ 120	+ 85	+ 30	0

Adding up the products we get 700, and, dividing by 12 to take the average, we find the mean product to be 58¼ watts. This practically agrees with the volt-amperes; for 4·16 × 14·1 = 58·6

Now, if we suppose a lag of the current to take place, we must shift the numbers on accordingly. Suppose there is a lag of 30°. This means that the current figures must all be shifted on by one-twelfth of a cycle—that is, one place out of the twelve, thus:

C	− 3	0	+ 3	+ 5	+ 6	+ 5	+ 3	0	− 3	− 5	− 6	− 5	− 3
V	0	+ 10	+ 17	+ 20	+ 17	+ 10	0	− 10	− 17	− 20	− 17	− 10	0
C × V	0	0	+ 51	+ 100	+ 102	+ 50	0	0	+ 51	+ 100	+ 102	+ 50	0

Adding up and dividing by 12 as before, we now find the mean power to be only 51 watts. But this agrees with what was said above; for to find the *true* watts we must multiply the volt-amperes by the power-factor, which is the cosine of the angle of lag. Now the cosine of 30° = 0·866. And 4·16 × 14·1 × 0·866 = 50·8 which is practically the same as that deduced by averaging.

Anyone who doubts that, when the lag is 90° there is *no power*, should verify it by shifting the current figures till the maximum comes opposite the zero of the volt series, and then form the products and take the mean.

The Alternator concluded

IRELAND

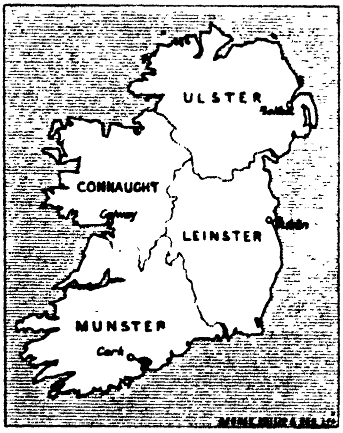
Physical Features of the Country. Poverty of its Inhabitants. Ulster and its Industries. Dublin. Cork. Kerry Mountains and Lakes of Killarney

Group 13
GEOGRAPHY
10

Continued from page 1277

By Dr. A. J. HERBERTSON, M.A. and F. D. HERBERTSON, B.A.

What the Country is like. In configuration Ireland is not unlike a plate, with a rim of mountains dipping down to a flat centre. On the east the rim is missing and the Midland Plain extends to the sea. Partly, perhaps, because of this arrangement of high and low land, much of Ireland is boggy, and lakes are numerous. A bog is something between land and water, made half-solid by dense, matted vegetation, which is cut and dried to form peat or turf. As there is hardly any coal in Ireland, peat forms the only cheap fuel. When bogs occur on hillsides the weight of water occasionally loosens their foundations, and a bog slide causes widespread ruin. In the plain many have been drained, and then the land, as in the English fens, is generally fertile. Ireland is neither thickly populated nor particularly populous. Owing to the absence of coal there is only one great industrial centre. The wet climate is not well suited for agriculture, but oats, barley, and potatoes are grown, the barley being distilled into Irish whisky. The rains keep its meadows luxuriantly green, giving the country the name of the Emerald Isle. Dairy farming and stock raising in the lowlands provide butter, bacon, poultry, and eggs for export. In the highlands the soil is scanty and of poor quality, the climate wet and raw, and the struggle for existence very hard. A whole family, with its few domestic animals, is often crowded into a cottage of one room, standing in the midst of a neglected and barren moorland croft. In many districts Irish is still spoken. From these congested western districts the more capable emigrate in large numbers across the Atlantic, which seems to offer a natural highway to a land of greater plenty.



78. THE PROVINCES OF IRELAND

The Four Provinces. Ireland is divided into Ulster in the north, the most prosperous region, with a large population of Scottish and Protestant descent; Leinster in the south-east, Munster in the south-west, and Connaught in the west. It is also divided into 32 counties.

Mountains and Lowlands. *Northern Ireland.* North of lat. 54° Ireland is mountainous. The highlands are not continuous, as in Scotland or Northern England, but broken into separate masses. In the lowlands between we find the towns and the more prosperous part of the population.

In the extreme west the Moy flows to Killala Bay, between the Nephin Beg and Slieve Gamph Mountains, with Ballina as the chief town. Between the Slieve Gamph and Sligo Mountains an arm of the Central Plain opens to Sligo Bay, on which is Sligo, a fishing centre. The Erne lowland, with its chain of lakes, the town of Enniskillen between Upper and Lower Lough Erne, and Ballyshannon on the estuary, opens to Donegal Bay, at the head of which is Donegal, between the Sligo and Donegal Mountains, both broad, high, barren, and poverty-stricken. The prosperous Foyle lowland lies between the Tyrone Mountains on the south, the Donegal Mountains on the west, and the Sperrin Mountains on the east. Omagh, Strabane, Lifford, and Londonderry are engaged in shirt-making and distilling. Londonderry, on the Foyle estuary, exports butter, pork, bacon, cattle, and grain to Liverpool and Glasgow, and imports timber and coal. Moville is a port of call for Atlantic liners. Equally prosperous is the Bann lowland, between the Tyrone and Sperrin Mountains on the east, and the Antrim and Mourne Mountains on the west. In the south it is drained by the Blackwater and Bann to Lough Neagh, the largest lake in Britain. Monaghan, Armagh, an old ecclesiastical centre, Dungannon, and Lurgan are the chief towns south of the lake, and north of it are Antrim and Ballymena. Lough Neagh is discharged by the Bann, with Coleraine as its port. The Antrim Mountains are of basalt, of which are formed the wonderful columnar terraces of the Giant's Causeway, east of Portrush. An important gap between the Antrim and Mourne Mountains, drained by the Lagan, has helped to make Belfast prosperous by giving it easy land routes to the plain.

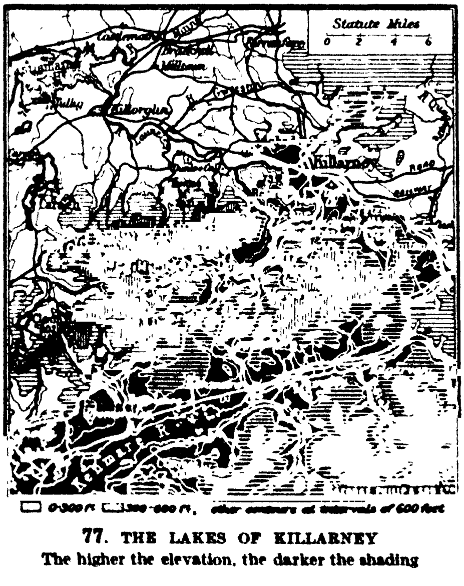
Irish Industries. Much more important is its situation on the coast, where coal can be cheaply obtained from the Ayrshire, Cumberland, and Lancashire coalfields, and raw materials from the Baltic ports. The linen manufacture from home-grown and Baltic flax is very important. The damp climate favours spinning, and the water has fine bleaching properties. The importance of shirt-making in many Ulster towns is now explained. Rope-making from Baltic hemp employs many hands. Shipbuilding is carried on on a large scale, and among many other industries distilling may be noted. Belfast, therefore, resembles the prosperous manufacturing centres on the other side of the Irish Sea, but unfortunately it stands alone in Ireland. Carrickfergus, on the north bank of Belfast Lough, is similarly engaged, and has important fisheries. Larne is the port for the Stranraer route across the narrow North Channel. South of Belfast are Donaghadee, and Downpatrick on Strangford Lough. The granite Mourne Mountains, rising to nearly 3,000 ft., are much visited for their fine scenery. To the south is Carlingford Lough, north of which Newry is built in the gap leading to Lough Neagh; Dundalk, on Dundalk Bay, an important railway centre with locomotive works, exports provisions; and Greenore has regular communication with Holyhead.

West Highlands of Connaught. All these lowlands are connected with the Midland Plain, which extends from the Irish Sea to the base of the mountains of Western Connaught. These are known as the Nephin Beg Mountains in the north, and the Connemara Mountains, with marble quarries, in the south, both rising to 2,500 ft. The coast resembles that of the West Highlands of Scotland, with many inlets, of which the largest is Clew Bay; they are separated by fine cliffs and headlands. The life of the peasantry is very similar to that of the Highlanders, but even harder than theirs. Poor grazing is eked out by poor fishing, and cottage industries. At the eastern base of the highlands is a chain of lakes—Conn, Mask, and Corrib—at the edge of the limestone Midland Plain. Galway, south of Corrib, at the head of Galway Bay, which would be a flourishing port in a richer district, exports the dairy produce of the better pastures, marble, and fish.

The Midland Plain. The Midland Plain contains much good agricultural and meadowland, but also much bog. The great Bog of Allen occupies a large part of King's County and Kildare. The Shannon, the largest river of Ireland, rises less than 300 ft. above the sea, and flows slowly across the plain, the whole centre of which is drained by it and its tributaries. In its upper course it expands into Lough Allen, south of which are Leitrim and Carrick-on-Shannon. Below Carrick the Boyle enters from the west, flowing through boggy country, with similar lake-like expansions. The Shannon continues of lake-like breadth to Athlone, at the south of Lough Ree, always an important town, because the river is there narrow enough to be bridged. It is the place where the main line from Dublin to Galway crosses the river. Below Athlone the Shannon expands to Lough Derg, and then flows through the gorge of Killaloe, between the Bernagh and Silvermine Mountains, to its estuary, at the head of which is Limerick, with a large provision trade, and some lace manufactures. West of the Shannon basin the land is drained by small rivers flowing to Loughs Mask and Corrib.

The Capital City. East of the Shannon basin, numerous rivers, rising to a great height, flow east to the Irish Sea. The largest is the Boyne, which flows through a country rich in antiquities and historical associations. Round towers and sculptured crosses are numerous. Tara, near Navan, the seat of the ancient kings of Ireland, is famous in song and legend. Drogheda, at the mouth, manufactures linen and exports the agricultural and dairy produce of the eastern plain. The Liffey, also flowing into the Irish Sea, rises in the picturesque Wicklow Mountains to the south. Dublin, the capital, on a magnificent bay, is built at the mouth of the Liffey. The surroundings are remarkably beautiful, but in spite of some fine streets and buildings, Dublin is not an imposing city. It is noteworthy that, like the capitals of England and Scotland, Dublin is on the east coast, showing how important proximity to Europe has been throughout our island history.

Southern Highlands of Leinster and Munster. South of a line drawn from Galway Bay to Dublin Bay, Ireland is again mountainous. As in the north, lowlands break the mountains up into separate masses, many of which are higher and more extensive than those of Ulster. The lower course of the Shannon lies in the highland region, and has already been described. East of the Slieve Bloom and Silvermine Mountains, which form its eastern margin, is the lowland drained by the Suir-Nore-Barrow. The Barrow—the main river—is formed by streams from the Slieve Bloom and the Bog of Allen, and flows due south between the Wicklow and Wexford Mountains on the east, and the mountains of Kilkenny on the west. The Nore, also from the Slieve Bloom, flows through past Kilkenny, parallel to the Barrow, but separated from it by hilly but good agricultural and grazing country. Anthracite coal is worked near Castlecomer; marble, lead, and other minerals near Kilkenny. The Suir, from the Silvermine Mountains, first flows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77. THE LAKES OF KILLARNEY

The higher the elevation, the darker the shading south, but is turned east by the spurs of the Knockmealdown Mountains, and flows past Clonmel and Carrick between mountains rising to 2,600 feet. It enters the Barrow at Waterford, at the head of Waterford harbour, which exports dairy produce and provisions.

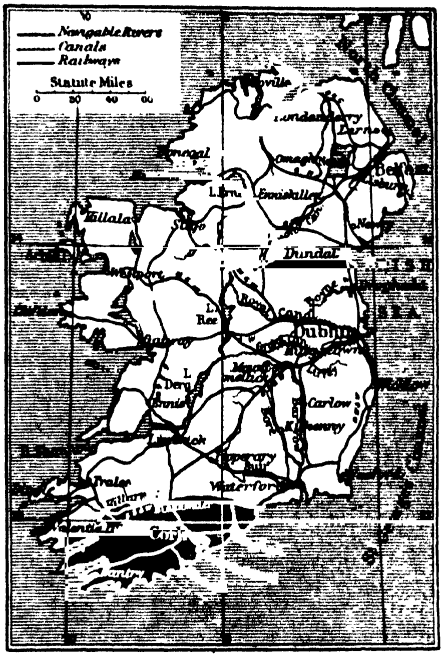
East of this lowland are the Wicklow Mountains, with magnificent peak, valley, glen and lake scenery. Of many lovely vales, that of Avoca is the most famous, with Arklow at its mouth. Minerals are numerous, and lead ore is exported from Wicklow. The southern slopes are drained by the Slaney, flowing to Wexford harbour, whence Wexford exports live stock, dairy produce, malt, and barley.

West of the Suir-Nore-Barrow lowland, the Slieve Bloom, Silvermine, and Knockmealdown Mountains form a nearly continuous belt of highlands. The rivers no longer run north and south in broad vales, but east and west in long, parallel valleys, which widen into lowlands at the mouths. The Blackwater flows along the northern base of the Boggeragh Mountains past Mallow and Lismore, and turns abruptly south to Youghal Bay, whence Youghal, with salmon fisheries, exports its agricultural and dairy produce. The Lee, coming down from the Kerry Mountains, flows east to Cork harbour, which opens to the south, and the Bandon in a parallel valley flows through similar mountain scenery, turning south-east to Kinsale harbour. Many of the fine natural harbours of southern Ireland are spoilt by bars at their mouths. Cork is one of the finest in the world, and could hold our entire Navy. It contains many islands, on one of which is Queenstown, where Atlantic liners call for mails and passengers. Distilling, brewing, bacon curing, tanning, glovemaking, and some woollen manufactures are carried on at Cork. The export trade in provisions is very large, and shipbuilding is important. Kinsale is a fishing port.

Kerry Mountains and Killarney. The south-west of Ireland consists of lofty and picturesque mountains running westwards down to the sea, forming a wild, rocky coast, with many headlands and long, narrow bays. Among the latter, notice Dingle Bay, Kenmare River, Bantry Bay, and Dunmanus Bay. The rivers are short and rapid, and afford excellent fishing. In the north, the mountains are known as Macgillicuddy's Rocks, with Carrantuol, over 3,000 feet, the highest mountain in Ireland, and Mangerton, almost as high. Among those towering peaks are embosomed the far-famed lakes of Killarney, with many islands, richly wooded like the shores. Much of Kerry is unproductive moorland. As little agriculture is possible, towns are few and population sparse. Round the dangerous coast fishing is important. On Valentia Island is a meteorological station, from which we receive the first warning of storms approaching from the Atlantic.

ISLANDS IN BRITISH WATERS.

The Isle of Man. The Isle of Man rises in the Irish Sea, midway between Strangford Lough and St. Bees Head in Cumberland, each less than 30 miles distant, whilst the Scottish coast is considerably nearer. The island is 33 miles long and 12 miles wide. The centre and south parts of the island are mountainous, with lovely glens opening to the sea. Snaefell, 2,000 feet high, is the highest point, and commands a fine view of the island and of the coasts of England, Scotland, and Ireland. Minerals are abundant, especially lead. Farming is extremely good; all round the coast fishing is important, and most of the towns—of which Douglas, Ramsey, and Peel are the largest—are situated there. The tourist traffic is immense in summer, when the island becomes the playground of Lancashire. Man preserves the right of self-government, a separate Parliament, known as the House of Keys, separate judges, or deemsters, and many relics of a long and interesting history.



78. MEANS OF COMMUNICATION IN IRELAND

The Channel Islands. These, the last shreds of our once great French possessions, are 80 miles from our own shores, and within 10 of the French coast. The largest are Jersey (45 sq. miles), Guernsey (25 sq. miles), and Alderney (4 sq. miles). Both population and language are of French origin, and the islands have Home Rule. The coast scenery is wild and imposing, and the surrounding seas are strewed with sunken rocks, and rendered still more dangerous by strong currents. In all the growing of early fruit and vegetables is important, and fine breeds of dairy cattle are grazed on the sunny meadows. The capital of Jersey is St. Heliers and that of Guernsey St. Peter's Port.

Continued

Continued from page 1312

MOSSES & LIVERWORTS. LOWEST PLANTS

Moss Colonies. Seaweeds. Diatoms. Mushrooms and Toadstools. Fairy Rings. Moulds. Rust. Mildew. Potato Disease. Yeast and Lichens

By Professor J. R. AINSWORTH DAVIS

MOSSES & LIVERWORTS—continued

Mosses are usually found matted together in extensive colonies, which are largely formed by a process of vegetative reproduction. The branches keep on growing, and their older parts decay, while the ends remain to form independent plants.

It is well known that peat is chiefly formed by the growth of peat-mosses on a large scale. These are far more dependent upon moisture than the ordinary sorts, and their branches and leaves are hollowed out into cavities, by which water is readily taken up.

Liverworts are lowly relatives of the mosses, presenting a great variety in form and habit, but possessing a life-history much like the one just described for a typical moss. Some of them are common on wet banks, or within the reach of spray from waterfalls. Many—*e.g.*, Marchantia [**209**, p. 1312]—are flat, green expansions, without distinction between stem and leaf, attached by numerous root-hairs to the underlying soil. In this particular case the egg-organs are borne on the under side of upright umbrella shaped-branches, while the sperm-organs are to be found in a similar position on mushroom shaped ones. There is also a special provision for vegetative reproduction in the form of little green cups, within which are produced minute rounded *gemmules*, capable of growing into distinct plants. The spore-capsule of a liverwort is not so complex as that of a moss. Its stalk does not elongate till the spores are ripe. These are contained in a rounded swelling [**210**], which may split open regularly or irregularly. Scattered among the spores there are usually a number of elastic threads (*elaters*), which assist in the dispersal of these microscopic bodies.

The higher liverworts somewhat resemble mosses in appearance [**210**], and are often found living among them. Some such forms grow on the bark of trees, and do not lose their vitality if they dry up. They are of a purplish colour.

THE LOWEST PLANTS (*Thallophytes*)

The plants with which everyone is familiar mostly belong to the groups which have now been described, for these include the forms which make up the green covering of the earth. Seed-plants, in particular, compel our attention by reason of their size, the conspicuous flowers so many of them bear, and their economic importance.

The present group, however, embraces a larger number of species than all the others put together, and these are of such varied kind that some are to be found almost everywhere. The plant-body is technically known as a *thallus*—*i.e.*, an expansion which is not divided into root, leaf and stem. The lower liverworts, as we have seen, are in much the same case. Thallophytes are conveniently divided into three great groups—Algæ, or Green Thallophytes; Fungi, or Colourless Thallophytes; and Lichens, which are of mixed nature.

ALGÆ (*Green Thallophytes*)

Though all of these possess the typical green colouring matter (chlorophyll), regarding which a good deal has elsewhere been said, this is in many cases obscured by the presence of brown or red pigment, which serves as a shield against excessive sunlight. We can therefore speak of "brown" and "red" algæ, as opposed to "green" algæ, in which the chlorophyll is obviously present.

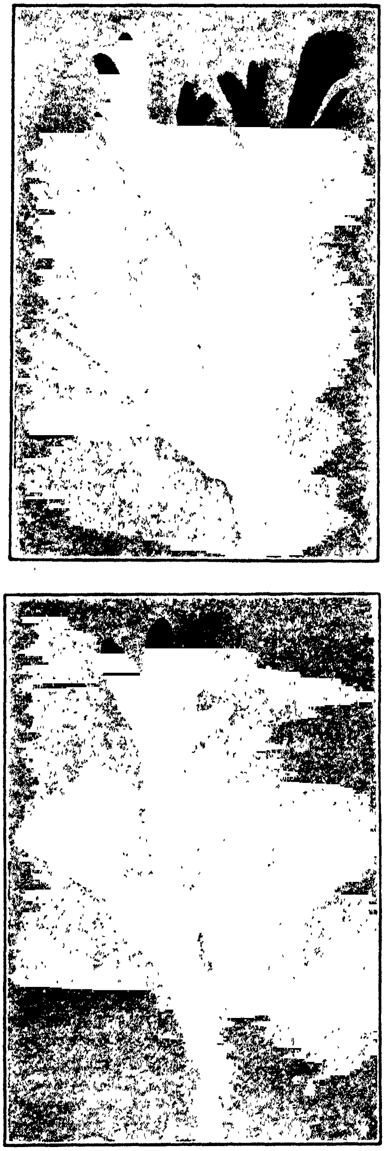
Bladder-wrack and Weather-glasses. The seaweeds which cover the rocks between tide-marks are the best known brown algæ, and attract the attention of every visitor to the seaside. The popular name for them is "wrack," and there are a number of common species. One of the most abundant is bladder-wrack. (*Fucus vesiculosus*) [**211** upper figure], the forking thallus of which is attached at one end, and when covered by the tide is buoyed up by numerous air-containing swellings. If a small piece of this or any other brown seaweed is placed in alcohol, the brown pigment will rapidly dissolve out, and a green hue will be assumed—*i.e.*, the chlorophyll will become visible. In winter and early spring the tips of wrack branches swell up and assume a yellow or orange tint [**211**, lower figure]. If such a swelling be held up to the light, a number of little round dots of darker tint will readily be perceived. Each of these is in reality a pit, or "conceptacle," lined by hairs, some of which are modified into egg-organs, sperm-organs, or both (according to the species). **217** is an enlarged view of a section through a female conceptacle, containing only egg-organs. Each of these is an ovoid body on a very short stalk, and containing eight egg-cells. The sperm-organs [**218**] are minute bladder-like structures borne on branched hairs, and giving rise to large numbers of excessively minute sperms. When a ripe egg-cell is liberated, numerous sperms are attracted to it, and one actually fuses with it, thus effecting fertilisation.

Beginning near low-water mark and extending some distance into shallow water we find the "Laminaria zone," so called after brown seaweeds of that name. They are larger and broader than the wracks, and the thallus is smooth or corrugated, according to the species.

It is these plants which are so often taken home by seaside visitors to serve as "weather-glasses" since, owing to the salt which clings to them, they become damp on the approach of rain.

Brown Seaweeds of Deeper Water. Large masses of seaweed are to be found drifting about in the ocean, especially in the Sargasso Sea, a huge eddy occupying several thousand square miles of the North Atlantic. The most notable form here to be seen is the "gulfweed" (*Sargassum bacciferum*), which is buoyed up by stalked floats resembling berries in appearance. A huge brown seaweed (*Macrocystis pyrifera*), with pear-shaped floats, native to the non-tropical parts of southern seas, attains the astonishing length of several hundred feet. Fucus and Laminaria are largely used as manure, and under the name of "kelp" were formerly employed in the manufacture of soda. As a source of iodine they are (especially Laminaria) still invaluable.

Diatoms [219]. These almost infinitely varied microscopic forms, which possess flinty coverings of great beauty, may be reckoned as the humblest of the brown seaweeds. They are to be found in both salt and fresh water, and even on the surface of damp earth. Large tracts of the ocean floor, especially in the Antarctic regions, are covered with fine "ooze" principally composed of their remains. Some diatoms are stalked and immotile, but the larger number are free, and, like many of the lowest plants, possess the power of movement. When examined under a microscope they may be seen gliding along in a very interesting and curious fashion.



211. BLADDER-WRACK (Fucus)
(Photographed by Prof. B. H. Bentley.)

Diatoms as Food for Animals. The surface layers of the sea and of lakes are inhabited by countless myriads of diatoms, which constitute the chief food of innumerable minute animals, especially the lowly cousins of shrimps and prawns. These little creatures in their turn are devoured by herrings and many other sorts of fish, so that man himself is indirectly indebted to diatoms for an important part of his diet. And this becomes still more obvious when we remember that oysters, cockles and mussels feed upon these lowly plants wholesale.

Red Seaweeds. Most of these inhabit moderate depths in the sea, and are unsurpassed for their beauty of form and colour. Many of them are torn from their moorings and cast up on the shore by storms. The reproductive processes are too complex to be discussed here. Some of the red seaweeds are strengthened by calcareous matter, and these "nullipores" are represented on our own coasts by branching forms and pinkish crusts which are to be found on rocks between tide-marks.

Seaweeds as Human Food. "Carrageen Moss" (*Chondrus crispus*) is a stoutly-built forking red sea-weed which grows on the coasts of Britain, and has been used in much the same way as isinglass. "Laver" is another edible species, with a fairly broad, branching thallus. It is exposed for sale in Scotland, and in South Wales is mixed up with dough and baked into a sort of bread.

Green Algæ. While red algæ are most exclusively marine, the green ones abound both in salt and fresh water. None of them are of great size, while large numbers are microscopic. Some of the larger forms are to be seen between tide-marks—*e.g.*, "sea lettuce" (*Ulva*), in which the flat thallus is of a brilliant green, and *Enteromorpha*, made up of tufted hollow threads. The group may perhaps be best illustrated by taking two or three typical species.

Chara [214]. Chara is a somewhat anomalous green alga, which is often to be found growing in dense masses in the ponds of chalk districts. It consists of a slender axis bearing circlets of branches, and suggesting in appearance a horsetail, though on a much smaller scale. The lower end is fixed in the mud by means of long, fine root-hairs. Upon the branches are groups of slender projections, which are possibly to be regarded as incipient leaves. The axis and its branches are covered by cells arranged in a spiral manner, and the whole plant is encrusted with carbonate of lime.

Reproduction of Chara. Towards the end of summer egg-organs and sperm-organs are developed in pairs on the branches, in association with the "leaves." The egg-organ is brown in colour and of ovoid shape, with a spiral covering, and a "crown" of pointed cells. It contains a single egg-cell, to which a passage leads down between the crown-cells at the time of maturity. The orange-coloured sperm-organ is a hollow sphere, the wall of which is made up of eight triangular plates, elegantly fluted. From each plate a sort of "handle" projects inwards, and this bears several long threads, composed of a large number of cells joined end to end. Within each of these cells a spirally-shaped sperm is produced, one end of which is provided with two long whiplike threads of living matter (protoplasm), the lashing movements of which propel it through the water. The ripe sperm-organ falls to pieces, and the innumerable sperms developed within it swim away. Fertilisation is effected as usual, by the fusion of the sperm with the egg-cell. The fertilised egg-cell, surrounded by its spiral investment, falls to the bottom of the pond, and remains dormant during the winter, germinating in the following spring into a new plant.

Movements of Protoplasm. Chara, and a related form (*Nitella*) which differs from it in certain details, have long been employed to demonstrate the movement of living protoplasm within vegetable cells. Seen under the microscope such a cell is found to possess a central space filled with sap, and surrounded by a layer of protoplasm which ceaselessly moves round and round within its delicate membranous investment. Such movement of living substance may also be seen in some of the cells of higher plants, a particularly good example being the hairs of stinging-nettle, which have a swollen base from which a long brittle thread projects, terminating in a little knob when uninjured. The thread, if lightly touched, can penetrate the human skin, when the escape of a minute quantity of the acrid sap sets up the familiar and unpleasant irritation which most of us have experienced. If an uninjured hair be examined under the microscope, the protoplasm will be seen to be largely broken up into branching strands, the substance of which is in constant movement; this the presence of innumerable minute granules renders quite obvious.

212. TOADSTOOL
(Photographed by Prof. B. H. Bentley.)

Spirogyra [215]. Many threadlike green algæ live in ditches and ponds, some attached by one end, and others simply floating. One of the commonest of the latter is Spirogyra, which is simply a row of hollow, cylindrical cells, bound by delicate elastic cell-walls. Each cell is lined by protoplasm, and the nucleus is suspended by delicate strands of the same substance in the central sap-filled space [215, right]. A spiral band of the external protoplasm is impregnated with chlorophyll, and in it are to be seen a number of little rounded bodies (*pyrenoids*) concerned with the manufacture of starch.

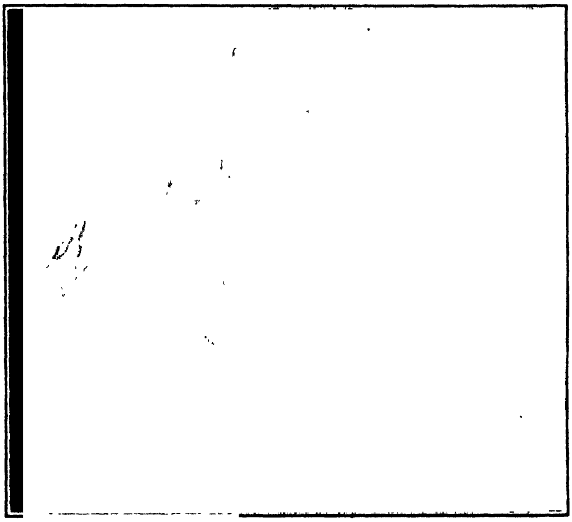
Reproduction of Spirogyra. During spring and summer, Spirogyra is constantly increasing in length by division of the constituent cells, and pieces are frequently separated to form new and distinct plants. But on the approach of autumn, the process of "conjugation" takes place, which is comparable to egg-propagation, but is simpler, inasmuch as there is only a faint indication of a distinction between egg-cells and sperms. The adjacent cells of two contiguous filaments send out processes which meet, fuse together, and make a conjugating tube [215]. Meanwhile, the protoplasm of each cell contracts into a rounded mass. One of these squeezes through the conjugating tube and fuses with the protoplasm of the other cell, to make a "resting-spore." This develops a firm covering, and remains dormant through the winter, growing into a new plant in the next spring. The filaments themselves break up and die.

Desmids [216]. If, during spring or summer, some of the mud from the bottom of a pond is examined under the microscope, it will almost certainly be found to contain some of these elegant little plants, each of which consists of a single cell. Many desmids are of extreme beauty, being only surpassed in this respect by diatoms, though, unlike these, they are not invested by flinty membranes. Some of them possess the power of movement. Desmids—and diatoms, also—conjugate in pairs [216*a*] to form resting-spores, which tide over the unfavourable winter season, like those of Spirogyra.

FUNGI (*Colourless Thallophytes*)

We have already had occasion to consider certain fungi which are associated with the roots of higher plants for mutual benefit, but this is a somewhat exceptional habit, as many of them (saprophytes) feed upon decaying vegetable or animal matter, while others (parasites) prey upon the living bodies of animals or other plants. Fungi are conveniently called " colourless " thallophytes to indicate the fact that they contain no chlorophyll, in the absence of which they are unable to use sunlight for the purpose of building up organic substance from water and carbon dioxide. They may, however, be of the most varied hues, including green. It would need a complete treatise to do justice to the wealth of forms included in the group, so we must content ourselves with considering a few of the commoner or more interesting types.

Mushrooms and Toadstools. The actual mushroom or toadstool plant consists of a mass of branching fibres, which ramify in the surface layers of the soil, and constitute what is technically known as the *mycelium*, or, in popular language, the " spawn." This gives rise to the stalked spore-producing structure which is seen above ground, and which is made up of closely interwoven and compacted threads [212]. When fully developed, the underside of the expanded top of a mushroom or toadstool will be seen to possess a large number of radiating plates, or " gills," on the surface of which the dustlike spores are produced in immense numbers. The gills vary in colour with the species, being, *e.g.*, in the edible mushroom, pink, brown, or black, according to age.



213. LICHEN.
(Photographed by Prof. B. H. Bentley.)

A thin section through part of a gill [220], when examined under the microscope, will show that the surface layer is made up of closely-packed club-shaped cells, drawn out into pointed projections, the ends of which swell up into spores. These are so minute that they are readily dispersed by the wind, and germinate into new plants under favourable conditions.

Fairy Rings. The fairy rings of our meadows are due to the gradual outward extension of an original clump of toadstools, the central patch being bare as a result of exhaustion of the soil.

Sponge Toadstools. A well-known edible fungus (*Boletus edulis*), living in woods, looks like a clumsily built brown-topped mushroom. Instead of gills, however, we find a spongy mass made up of elongated tubes lined by spore-producing cells. A stalkless member of the same group (*Polyporus*) is often seen as a sort of semi-circular plate projecting from the trunk of a tree or a decaying gatepost. One species is used for preparing tinder. The " dry-rot " of timber is due to another toadstool belonging to this group.

Puff-balls. These are closely related to the toadstools, but the spore-producing bodies are quite differently shaped, being rounded structures within which spores are developed, to be liberated by the bursting of the mature puff-ball.

Morels and Truffles. These differ from the preceding in that their spores are developed within tubular cells instead of projecting freely from the surface. The spore-producing body of the edible morel (*Helvella*) is club-shaped, the swollen part being yellow in colour, and its surface studded with projections.

Truffles live entirely underground, where their spore-producing bodies are developed as tuber-like thickenings. They possess a characteristic odour, and, as is well known, are hunted out with the aid of pigs or dogs.

Edible and Poisonous Fungi. The best-known edible forms are mushrooms, Boletus edulis, a large species of puff-ball (*Lycoperdon deliciosum*), morels and truffles; but many others are more or less eaten. It unfortunately happens that numerous species are virulently poisonous, and as some of these closely resemble edible forms it is wisest to refrain from making gastronomic experiments on the group, unless the advice of a specialist is available.

Moulds. It is a familiar fact that jam, cheese, bread, fruit and many other articles of food, as well as leather and so forth, are liable to become " mouldy " if kept in a damp place. This is because they have been infected by the spores of the lowly fungi known as " moulds," of which a great variety are known to botanists.

Green Mould (*Penicillium glaucum*) [221]. This common form is often to be seen on oranges and bread, among many other things. The plant-body, or mycelium, is made up of excessively delicate branching threads, some of which grow into the air and assume the form of antique candelabra, the branches of which give rise to rows of spores that are disseminated by the least breath of air. A more complicated process of reproduction, involving fertilisation, has also been described. The blue mould

(*Aspergillus*) of cheese is broadly similar, but the spore-bearing branches end in swellings, from which numerous long chains of spores radiate.

White Mould (*Mucor*). This is often to be seen on bread and horse-dung. The mycelium is made up of whitish, cobwebby fibres, from which long spore-bearing branches rise into the air. Each of these ends in a rounded swelling, within which numerous spores are produced. There is also a process of conjugation between specialised mycelial branches, by which resting-spores with firm investments are produced. These are able to remain dormant for some time, and thus enable the fungus to combat unfavourable surroundings.

All the fungi so far described are saprophytes, which live upon dead organic matter; but some of the moulds infest living plants, such as cereals, peas and vines. Besides these there are many other parasitic forms, of which one or two deserve special mention.

Ergot of Rye (*Claviceps purpurea*). During spring the young ears of rye are liable to be attacked by ergot, which is at this time in the form of a delicate mycelium, infesting the ovaries of the flowers, and producing innumerable minute spores, which are dispersed by the agency of flies and other small insects. These are attracted by a sweet fluid—" honey-dew "—that exudes from the diseased ovaries. When the grain ripens, the mycelium is compressed into a hard body known as an " ergot " [222], which remains dormant during the winter. In the following spring a number of spore-producing bodies grow from this, each with a swollen end [223], in which there are a number of pits containing groups of elongated spore-cases. The slender spores developed inside these cases are dispersed by the wind, and infect the young rye-plants.

Wheat Rust, Wheat Mildew and Barberry Blight. One species of fungus in the course of a complicated life history passes through three stages, respectively known as wheat rust, wheat mildew and barberry blight. The first of these stages (*Puccinia graminis*) makes its appearance in spring on the leaves and stems of wheat, giving rise to rusty-looking patches, in which numerous rust-spores are produced [224]. By means of these the fungus propagates and spreads during the summer. On the approach of autumn the patches assume a black colour, indicating that the mildew stage is reached [225]. Spores of a different kind are now produced, and these remain in a resting condition through the winter. They germinate in spring, and give rise to a third kind of spore, which does not attack wheat, but barberry, producing " barberry blight " (*Æcidium berberidis*) [226]. This consists of a branching mass of delicate threads within the leaves of the host, from which blight spores take origin. They are of an orange colour, and are developed in little cups on the under sides of the leaves. They are scattered by the wind, and such of them as alight upon wheat may germinate into wheat rust.

Potato Disease (*Phytophthora infestans*). The delicate mycelium of this formidable parasite ramifies within the delicate tissues of the potato-plant, and pushes out branches to the exterior through the stomata of the leaves [227]. These bear ovoid spore-cases, within each of which are produced motile spores that swim about in the moisture present and disseminate the disease. Egg-organs and sperm-organs are also present on that part of the plant within the host, and the fertilised egg-cell becomes an egg-spore, which is invested in a firm coat, and remains in a dormant state during the winter.

Yeast. If a little yeast is examined under a strong power of the microscope it will be found to contain innumerable ovoid yeast-plants, each consisting of a single cell and reproducing for the most part by a process of budding [228]. Under unfavourable conditions a yeast-plant may become a spore-case, within which are developed four spores that are able to remain in a state of suspended animation for a long time, should the surroundings still be adverse. They are so minute that they can be dispersed by the wind for great distances, and some of them are likely to reach a spot where circumstances are in their favour.

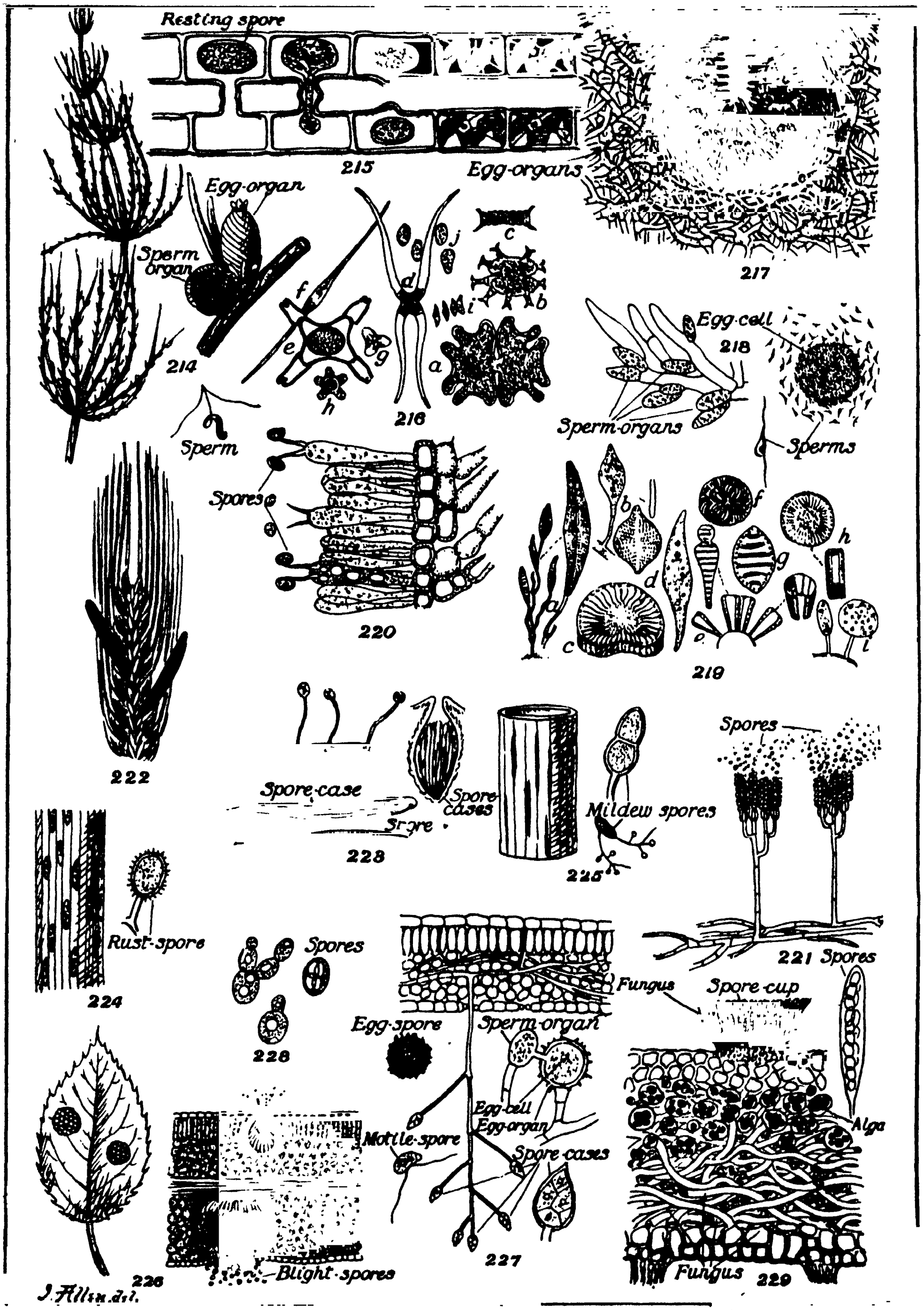
Alcoholic Fermentation. The most remarkable fact in regard to the vital processes of yeast is that when placed in a sugar-containing solution it is able to break up the sugar with production of alcohol and carbon dioxide. This " alcoholic fermentation " is clearly of great economic importance. It is the production of gas by the yeast which is mixed with dough that causes the bread to " rise "—*i.e.*, to become of spongy texture instead of remaining dense and tough.

LICHENS

These familiar plants are found everywhere, in the form of variously coloured crusts on rocks and walls, tufted growths on the trunks of trees [213], and so forth. As already mentioned, a lichen is a joint-stock company, consisting of an alga associated with a fungus, both of which can clearly be seen in a thin section placed under the microscope [229]. Spores developed in club-shaped cases are produced in special cup-shaped outgrowths, or it may be thickened projections. The spore-cases are the result of growth subsequent to a process of fertilisation.

Two lichens are of particular economic interest. One of these is the so-called Iceland moss (*Cetraria Islandica*), which is used as a food in Iceland, and was formerly valued as a remedy for chest diseases. The other is reindeer " moss " (*Cladonia rangiferina*), which grows in dense masses on the ground in high latitudes, and during the winter forms the almost exclusive food of the reindeer.

Botany concluded



214. CHARA. 215. SPIROGYRA. 216. DESMIDS*. 217-8. FUCUS. 219. DIATOMS†. 220. MUSHROOM (section). 221. GREEN MOULD. 222-3. RYE ERGOT. 224. WHEAT RUST. 225. WHEAT MILDEW. 226. BARBERRY BLIGHT. 227. POTATO FUNGUS. 228. YEAST. 229. LICHEN (section).

* Desmids.—*a.* Euastrum verrucosum. *b.* Didymocladon furcigerus. *c.* Scenedesmus quadricauda. *d.* Closterium setaceum (in conjugation). *e.* Tetmemorus lævis (in conjugation). *f.* Closterium setaceum. *g.* Aptogonum desmidium. *h.* Staurastrum margaritaceum. *i.* Scenedesmus obliquus. *j.* Scenedesmus obtusus.

† Diatoms.—*a.* Cocconema lanceolatum. *b.* Doryphora amphiceros. *c.* Campylodiscus. *d.* Gynosigma balticum. *e.* Meridion constrictum. *f.* Eupodiscus argus. *g.* Sphinctocystis elliptica. *h.* Cyclotella Kutzingiana. *i.* Pododiscus jamaicensis.

Group 24

PHYSICS

10

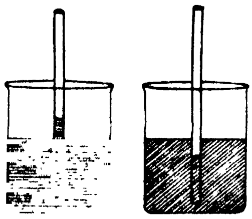
Continued from page 1270

SOME PROPERTIES OF MATTER

Capillarity. Viscosity. Compressibility. Cohesion. Hardness. Rigidity. Elasticity. Plasticity. Ductility. Diffusion

By Dr. C. W. SALEEBY

Capillarity. This word is derived from the Latin name for a hair, and is applied to the facts which are observed when liquids are placed in very hair-like or slender tubes. As every one has noticed, if such a tube be dipped into water, the water will rise some distance in it. The case is exactly similar with tea, which will run up into a lump of sugar. Furthermore, the surface of the water in the tube will be curved concave upwards. If, now, a similar tube be dipped into mercury, the mercury within the tube will actually stand at a lower level than that outside it, and the surface of the mercury in the tube will be convex upwards. These facts are all entirely dependent upon the same molecular attraction that we have already called surface tension—that is to say, upon the relations of the surface tensions of the water, the mercury, the glass, and the air. This fact of capillarity cannot now detain us further, but we may briefly note that it is of great importance to the botanist, who finds in it a factor which helps to determine the rise of the sap in a tree—a process which, in some measure, corresponds to the circulation of the blood in an animal.



DIAGRAMS SHOWING CAPILLARITY

Some other Properties of Matter. Briefly, we must name certain other properties of matter which are of less importance from the theoretical point of view, but which cannot be ignored. *Viscosity* is a property possessed in varying measure by all fluids, both liquids and gases. In consideration of the physics of fluids, the fact of their viscosity has to be ignored owing to the complications which it introduces ; and so we have to imagine what physicists call a *perfect fluid*, which has no viscosity—that is to say, one which in passing over any surface exercises no force upon it except that force at right angles which we described under *fluid pressure*. That fluids vary in their viscosity everyone knows who has compared methylated spirits with treacle ; both are fluids, yet how profoundly different is their physical state. *Compressibility* is another occasional property of matter, the word being used to describe the fact that when matter, liquid, gaseous, or solid, is subject to pressure, its volume is reduced, or may be reduced. Reference has already been made to the contrast between liquids and gases in this respect, the former having for long been regarded as incompressible. We cannot now accept, however, the old division of fluids into *compressible fluids* and *incompressible fluids*, names formerly applied to gases and liquids, since it is now known that liquids are not incompressible. When we come to look into this property of matter, it is evident that it must depend upon a lack of continuity in the structure of matter—that is to say, if all the space occupied by a given volume of any kind of matter, looked at as a whole, were really filled everywhere by the minute particles constituting the mass, the mass would necessarily be incompressible. Hence, we must conclude that the compressibility of matter depends upon its discontinuous structure ; it is better not to say that it depends upon its porosity, for that term is better confined to describe the character of bodies, either liquids or solids, whose behaviour is such that their structure must be conceived as containing numberless pores or apertures or interstices, into which other matter from without can enter. *Cohesion* is another property of matter to which considerable reference has already been made. It is not worth while to draw any distinction, such as has been drawn between cohesion and adhesion. In considering surface tension, we are really considering a consequence of the same force as that which, when displayed in the interior of a body, is called cohesion, and this is, again, in reality the same force as that which is called adhesion, and is displayed between smoothly fitting surfaces of two bodies, such as metal plates when these are pressed closely together so as to squeeze out the air from between them.

Hardness. Hardness is another property of solid matter, and is usually expressed by means of a scale that indicates, in order, a number of substances so arranged that the first can be scratched by the second, the second by the third, and so forth, but not vice versâ. Hardness is not merely a matter of density of a substance, nor does it depend merely upon its chemical composition ; unquestionably it depends upon molecular forces, and it is worth noting that it is often associated with *brittleness*. The scale of hardness invented by Von Mohs is as follows.

1. Talc. This can be cut by the thumb-nail.
2. Rock-salt, or selenite.
3. Calc-spar, or Iceland spar.
4. Fluor-spar. This can be cut by a steel knife.
5. Apatite, or asparagus stone. This can be scratched by a knife.
6. Fel spar—its purity being essential. This can be scratched only by the hardest steel.
7. Rock crystal, or quartz. This is able to scratch glass or an ordinary steel knife.

8. Topaz.
9. Sapphire.
10. Diamond, which cuts glass.

We may compare the phrase, "as hard as adamant" (from the Greek *adamas*, unconquerable, whence the poets have formed the word adamant to mean the diamond).

Rigidity and Elasticity. *Rigidity* is another property of matter which enables a body to resist tendencies towards change of form. *Elasticity* is another property of many bodies which has been very variously defined. According to some definitions (and with these common usage certainly agrees), indiarubber is a far more elastic substance than steel. According to other definitions, steel is far more elastic than indiarubber. The elasticity of the indiarubber is much more obvious than that of steel; but if the essential part of our conception of elasticity be that an elastic body is able to return to its original bulk and shape after the application of a force which has altered one or both, then steel must be regarded as more elastic than indiarubber, since its restoration to its original condition, when the disturbing force has been removed, is far more complete and more nearly perfect than in indiarubber. We must remember that elasticity may be expressed in two opposite ways. A gas or a ball of indiarubber is elastic because it springs back again to its original bulk after it has been compressed, while a piece of indiarubber is similarly elastic in that it returns to its former length after it has been extended. This property of elasticity is extremely important in a higher realm than that with which physics mainly deals, for it is one of the most important properties possessed by muscular tissue. The greater part of the act of expiration is mechanically accomplished, without any nervous or muscular effort of ours, by means of the elasticity of the muscles of inspiration, aided by the elasticity of the ribs.

Plasticity. The opposite property of elasticity is *plasticity*. The art of moulding in clay is called plastic art—wet clay being a substance which has no elasticity worth mentioning, and which is, therefore, perfectly suited for the purpose of the modeller. Every solid has a limit of elasticity, and if strained beyond that limit undergoes such a molecular change as to make it plastic. But even yet we have not completed the list of properties of this kind. The reader will have noticed that latterly we have been giving merely definitions of words and illustrations of their meaning; we have been doing nothing to explain the facts that are described. All these facts are doubtless dependent upon molecular conditions and forces, which determine whether the body shall be elastic or plastic, rigid, hard, or brittle.

Ductility. *Ductility* is a property of many metals, in virtue of which they can be drawn into wire. We may contrast, for instance, iron wire, which is so familiar, with the results that are reached when one makes a wire of lead, the most plastic and least ductile of metals. It might be thought that the same metals which can readily be extended in the form of wire would be capable of being extended in the form of flat plates; this property is known as *malleability* (from Latin *malleus*, a hammer). But, as a matter of fact, lead is exceedingly malleable, and can be hammered out to very considerable thinness, though it can scarcely be drawn out into wire at all. The property upon which ductility, as distinguished from malleability, depends, is called *tenacity*, and is possessed in the highest degree by the best steel. Very few people have any idea of the extraordinary tension, or longitudinal stress, which is borne by the steel wires of a good piano.

Even though we are totally unable to explain these various properties of various substances in terms of molecular forces, we are, at any rate, able to show that some of them vary with varying temperatures, as we would expect them to vary if the theories already stated as to the relations between heat and molecular energy were true. According to those theories, for instance, the process of adding heat to a solid body must imply an increase of its molecular motion in the direction of the state which obtains in the case of a gas. Hence, we are not surprised to find that the heating of a solid reduces its cohesion.

Another Property of Gases—Diffusion. The last property of any kind of matter which we need to consider here is the property of diffusion, which is possessed by gases, and which becomes quite intelligible if we recall what has already been said regarding the molecular motion in a gas, and what we have now learnt to know as the kinetic theory of gases. Recalling the conceptions already noted, let us consider what will be liable to happen if two different gases be poured into a vessel one above the other; there is no surface tension in this case. Does it not seem inevitable that at what is called the interface, or the level where the two gases meet one another, there will be a very marked tendency to intermixture? Such intermixture indeed occurs, and is known as *diffusion*. The rate of diffusion is found to follow an absolute law, and is strictly consistent with—indeed, is the strongest proof of—the kinetic theory. Diffusion occurs in all fluids, not merely in gases, though the diffusion of liquids, as one might expect, is much less rapid, and is complicated by the facts of surface tension. For instance, oil and water do not diffuse into one another—they do not "mix." The relative weight of liquids also affects their mutual diffusion.

A Concluding Note on Matter. But before concluding this part of our subject and passing on to consider various forms of energy, such as heat, sound, and light, it is necessary to return to a supremely important subject. On page 312 we made some reference to it, and it has been incidentally referred to in our discussion of certain of the properties of matter. This subject is none other than the very nature of matter itself. Even since those remarks were written, much remarkable and important evidence, which the experimenters have not yet published themselves, and which, therefore, can only be alluded to here, has been forthcoming in favour of the great truths which we laid down, and in drawing to a conclusion the part of our course which deals especially with matter, the opportunity must be taken for endeavouring still further to clear up the confusion which occurs in connection with this subject, and still further to establish truths which will be found of the utmost importance, not only to modern physicists, who have done so much to demonstrate them, but also to students of certain subsequent courses of the SELF-EDUCATOR, and especially of those which will deal with the science of mind or *psychology*, and with *philosophy*.

The Old View of Matter Untenable. Already we have rejected the idea that the units of matter are hard things, like "foundation stones." Further, we have carefully distinguished between mass and weight, and have noted that weight is, so to speak, accidental, and that mass is perhaps the prime character of matter. Further, we have seen that it is the property of inertia from which our notion of mass is derived; but we also found that, according to the most recent investigations, the inertia of matter must be looked upon as electrical inertia, and matter itself as an electrical phenomenon. The final conclusion to which we came was that matter is merely a particular form of energy. We noted also that the belief in the conservation or the eternal persistence of matter —quite recently held by the chemist—can no longer be maintained in the light of the facts which are now rapidly being discovered and multiplied, of the disintegration—if not, indeed, apparent annihilation—of matter under certain conditions. Now, before we pass to the greatest fact of physics, which is the doctrine of the conservation of *energy*, it is highly necessary to clear up once and for all our ideas as to the proper use of this word. Energy, in the philosophical and scientific use of that word, does not mean possibility for action or capability for work; it implies an idea much more profound and important than any which those words convey. Neither in the original use of the word by Dr. Thomas Young, who introduced it, nor in its use by any of the great makers of physics since his day, does the word energy describe an attribute of matter. The importance of gaining as clear a notion as the human mind will permit of the real nature of energy lies first of all in the fact that the new theory of matter, which is reducing matter to something like its proper importance, necessarily directs more and more attention to that of which matter, as we are now beginning to see, is but a temporary manifestation; and, secondly, in the fact that, by a sort of poetic justice, we find the latest developments of physics to have completely destroyed that preposterous doctrine of materialism which, so popular thirty years ago, was based upon physical conceptions that sound simply mediæval to modern students of the subject—a doctrine which cannot claim at the present day a single consistent supporter of any note whatever, even Professor Haeckel being now or recently engaged in the highly necessary attempt to show that his philosophy, built upon a belief in the eternal persistence of matter, can stand even when that belief has been demonstrated to be untrue. Nor will it do to regard matter as a form of ether, since—even on that theory—it is the energy displayed in or by the ether that is the essential fact of matter.

Energy and Materialism. In modern scientific thinking the word energy is used to describe the *something*, the *power* which is really the underlying and essential fact of all facts and all phenomena, except the facts and phenomena of mind—the relation of which to the idea of energy will be discussed in the course on PSYCHOLOGY. Certainly such a definition cannot satisfy the physicist, nor is there any physicist who is perfectly satisfied with any conception that he can form of the nature of electricity—obviously necessary to an understanding of that electrical phenomenon which we call matter. But though the new theory of matter is at present so unsatisfying from the point of view of exact hard-and-fast science, yet it is already able to perform an incalculable service for philosophy. The old view of the nature of matter led directly to materialism, but this doctrine is now merely an obsolete absurdity. Founded, like half a hundred theological systems, in accordance with the scientific knowledge of the time, it has to yield, as they have had to yield, to the inevitable advance of such knowledge. The great French philosopher and mathematician, M. Poincaré, in his "Science and Hypothesis" (translated into English a few days ago), has commented, with French lucidity and brilliance, upon the fact that we are now compelled to regard our conceptions of matter as symbolic of a Power which is essentially unknowable, and the existence of which we can recognise only in its manifestations. Now, the gravest dogma of materialism is its fearful assertion that mind is a mere function—a transient function—of matter; but in the light of recent physics this is to say nothing—it is to describe mind, that of which alone we have any immediate knowledge, as an occasional function of a symbol—a symbol of a Something Else which we cannot know.

Continued

Continued from page 1283

WEEDS: PASTURES AND MEADOWS

How Weeds are Introduced. Their Suppression. Annual and Perennial Weeds. Grass and Hay Production. Manuring and Irrigation

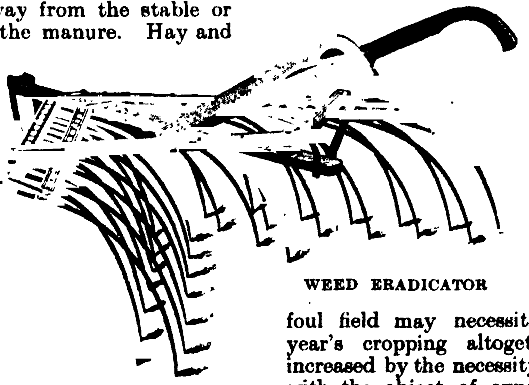
By Professor JAMES LONG

ERADICATION OF WEEDS

It is an old proverb that " A weed is a plant out of place " ; thus the wheat plant is a weed in a barley field, and vice versâ. Where weeds are practically suppressed, a farm is regarded as clean ; where, on the contrary, they grow with freedom, the land is termed foul. One of the most costly processes in agriculture is the cleaning of a foul farm, for the land is actually in possession of perennial and other weeds of the worst character, which are most difficult to suppress. Large numbers of the most prominent weeds are annuals, and, therefore, easily destroyed by ordinary means; but the worst of weeds, which are chiefly perennial, are only eradicated by hand-labour or deep ploughing. These, which are the farmer's worst enemies, include couch or twitch, dock, thistle, nettle, buttercup, daisy, coltsfoot, ragwort, knapweed, and bindweed; while among the worst of annuals are charlock, poppy, wild radish, mayweed, and dodder. The worst weeds, however, are not all found upon the same soils ; they have their preferences, some growing naturally upon the clays, others upon the chalks, and others again upon the sands. Thus they may indicate the class of soil which lies beneath the surface.

How Weeds are Introduced. Weeds may be introduced to the land through the seed which finds its way from the stable or the cattle-house into the manure. Hay and straw commonly employed for stock as commonly contain a more or less important proportion of dried weed plants, which shed their seed. Grass seeds, too, present in the hay, are frequently conveyed in the manure to the arable land; hence one reason in favour of allowing manure to heat before it is ploughed under the soil, for in the process of decomposition the seeds are destroyed. Where a corn stack has been threshed, weed seeds are deposited in large quantities, and one of the commonest sights on the average farm is the growth of docks and thistles around the stackyard, or in the corner of the field in which a stack has stood. Many weeds are conveyed from the plant to the field by the wind; others adhere to the feet of birds, and are deposited elsewhere. Again, a field may be easily inoculated with weeds by the employment of impure seed, especially that which is too often used by careless farmers —we refer to the sweepings of the hay-loft. The roadsides, the hedgerows, unclean land on an adjoining holding, all contribute to the labour of suppressing weeds on a farm which is well managed, and nothing is more essential in clean farming than the extension of the labour of weed suppression to every hedgerow and to the sides of the road which adjoin the farm.

Why Weeds Need Suppression. Weeds occupy the space which should be in the possession of cultivated plants. It is obvious that there is not room in a well-manured field for the growth of both weeds and crops. If weeds are numerous they obtain the mastery, and while the crop is thinned, the soil becomes foul, entailing great cost in cleaning and feeding. Weeds rob the cultivated plant of the food which it needs, of the moisture which enables it to appropriate food, and of the light, which is so essential to healthy growth. There are weeds, like ramsen and meadow saffron, which communicate their flavour to milk and butter, and which must at any cost be suppressed on land occupied by a dairy herd. Where weeds are numerous and their growth rank, they clog the reaper in the process of cutting and tying the corn, and not only are they the cause of frequent damage or even breakage of machinery, but they delay the work, to the great annoyance and disappointment of the farmer.



WEED ERADICATOR

If weeds are allowed to have their way for a short time they make the cultivation of land for an immediate crop practically impossible. A foul field may necessitate the omission of a year's cropping altogether, and this loss is increased by the necessity for several ploughings, with the object of exposing the roots of the weeds to the destructive heat of the sun. Where land is kept clean there is no necessity for summer fallowing of this character. Weeds harbour many of the pests of the farm, those among the fungi as well as insects. Farm pests of the worst type are seldom dangerous on land which is kept clean and in good heart. A careful examination of a truss of hay or a few sheaves of corn, whether wheat, barley, or oats, will quickly inform the student of farming how easily weed seeds are introduced into the soil and how difficult it is to suppress their growth in the existing state of our knowledge, except by persistently following the ordinary plan adopted in cleaning land.

How to Suppress Weeds. One of the most prominent and destructive of weeds is the yellow-flowered charlock, or kedlock, or wild mustard, which many farmers have in the past attempted to destroy by "heading"—*i.e.*, cutting off the head or flower with the scythe or hook. This practice is most destructive and costly, and should never be adopted. The charlock may be removed by hand-pulling, or, still better, destroyed by spraying with a solution of sulphate of copper to which quicklime has been added. Preparations for spraying a variety of crops are obtainable from the manufacturers of spraying machines, and especially of the Strawson apparatus.

Although it is possible by frequent ploughing at sufficient depth to destroy docks, thistles, and nettles, and similar deep-rooted, tenacious plants, by far the best plan is to extirpate them by hand. Annual weeds are easily destroyed by harrowing during dry weather, and in large part checked by the introduction of a flock of sheep, especially on the stubble after the removal of the corn, with the object of their consuming the weeds before the majority have shed their seed. It has been remarked that the poppy, the most gaudy as well as one of the worst of weeds, may produce over 10,000 seeds on a single plant; hence the enormous importance of preventing the seeding of this weed.

Weeds and Cultivated Land. Weeds which love wet soil quickly disappear when it has been drained, while by the process of high cultivation—by which we mean the liberal supply of manure—most of the weeds in pastures and meadows vanish, owing to what we may term the better fighting power of the cultivated grasses and clovers, which, in response to an increased supply of food, develop more vigorous powers of growth. Thus the wild plants, common in a poor pasture, disappear as the pasture improves. Moss is seldom found in a grass field in high cultivation. The buttercup, while thriving in a rich soil side by side with the cultivated grasses, quickly diminishes under the influence of lime, whether applied as quicklime or in the form of basic slag.

THE MOST OBNOXIOUS WEEDS OF THE FARM

A = Annual. B = Biennial. P = Perennial.

Arable.	*Meadow and Pasture.*
Corn Cockle, A.	Rest Harrow, P.
Chickweed, A.	Buttercup, P.
Charlock, A.	Daisy, P.
Wild Radish, A.	Hogweed, B.
Willow-weed, P.	Knapweed, P.
Coltsfoot, P.	Cowslip, P.
Mayweed, A.	Dandelion, P.
Oxeye Daisy, P.	Self-Heal, P.
Bindweed, P.	Plaintain, P.
Knot Grass, P.	Sorrel, P.
Nettle, P.	Dock, P.
Dock, P.	Ladies' Smock, P.
Goosefoot, A.	Ladies' Bed Straw, P.
Horsetail, P	Ragwort, P.
Poppy, A.	Spear Thistle, B.
Spurrey, A.	Marsh Thistle, B.
Shepherd's Purse, A.	Meadow Thistle, P.
Groundsel, A.	Yellow Rattle, A.
Sow Thistle, P.	Mallow, P.
Dodder (clover fields), A.	Meadow Saffron, P.
Broomrape (clover fields), P.	Ramsen, P.
	Sedge (wet pasture), P.
	Rush (do.), P.
	Moss (do.), P.

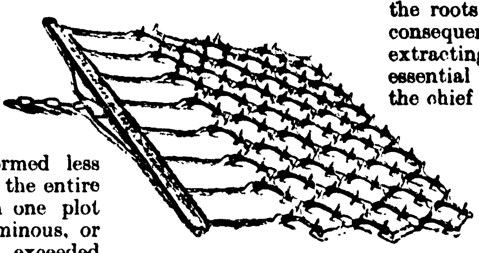
PASTURES AND MEADOWS

Distinction Between Meadows and Pastures. A *pasture* is permanent grassland used for the grazing of stock. *Meadow* land, on the other hand, equally permanent, is land which is usually mown, and subsequently grazed, although, where it is again intended to mow the crop, stock should not remain upon it after the first week in February. In some districts it is customary to mow a meadow in alternate years, grazing during the years between. Pasture land, upon which stock are fed with cake or corn, may improve in quality from year to year, for the manure they produce is all retained, while its value is improved owing to the extra food consumed. Thus the animals may return to the land a larger amount of fertilising matter than they extract from it. Further, the continual treading of stock keeps it compact and induces the finer grasses to grow stronger.

If the herbage of two fields of identical character—the one being a pasture and the other a meadow—is examined, it will be noticed that it differs in variety and character. If, too, one part of a meadow is skilfully manured from year to year, and the other part unmanured, it will be recognised that a great change has been effected in the composition of the herbage. On the unmanured land the plants grown will be in greater variety; there will be more weeds and fewer grasses and clover. On the manured land the number of weed plants will be diminished, while the number of clovers and grasses will be increased.

The Improvement of Meadows. Where meadows are mown annually, they may still be enabled to improve in quality under a regular and well-devised system of manuring; the soil will thus increase in its fertilising value, while both the quantity and the quality of herbage will improve. Some years ago the writer was shown the experimental grass plots at Rothamsted by the late Sir John Lawes, who especially remarked on the varied character of the herbage upon each, as well as upon the remarkable influence which the manures had exerted. Over a period of years heavy manuring upon various plots had resulted in the increase of the hay crop to some 3¼ tons per acre, whereas, where no manure was employed, the crop only just exceeded 1⅛ tons. Again, over a period of seventeen years, the total quantity of hay produced by the employment of large dressings of superphosphate, nitrate of soda, sulphate of ammonia, sulphate of potash, and sulphate of soda, reached from 62 to 72 cwt. per acre, while the addition of silicate of soda increased the crop to 85 cwt.

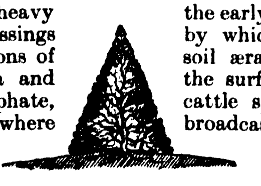
Manuring and Hay. To these facts we may add that the composition of hay, from a feeding point of view, is also changed where manuring is systematic. For example, the employment of farmyard dung was followed by a marked increase in the composition of the crop in potash and phosphoric acid and a decrease in nitrogen and lime. We have already shown that the varieties of plant growing on manured land are reduced in number. At Rothamsted, while the grasses proper never formed less than some 50 per cent. of the entire herbage, they reached on one plot 99 per cent. The leguminous, or clover, herbage never exceeded 40 per cent., but in one instance there was positively no clover at all. Again, the remaining herbage, chiefly consisting of weeds, was so large upon one plot that it reached 40 per cent., and so small upon another that it did not reach 1 per cent. If, therefore, by the intense farming of grass-land weed plants can be produced and clovers increased to the extent to which these figures point, it is obvious that the benefit to the farmer from the point of view of quality may be as great as that from the point of view of quantity.



A CHAIN HARROW

When Grass-land is Profitable. Grass-land can make no profitable return unless it is well cultivated. There are tens of thousands of acres within easy distance of the metropolis which do not make a gross return of £5 a year, and yet, under other systems of cultivation, this same land is equal to the production of ordinary crops worth, at least, double the money. In many cases market gardeners and nurserymen very largely exceed this figure, and there is little doubt that in some as much as £1,000 per acre is returned per annum by the aid of glass on the same class of soil.

The growth of grass for hay on heavy land is best stimulated by annual dressings of dung and artificial manures ; 5 tons of dung with ½ cwt. of nitrate of soda and 2 cwt. each of kainite and superphosphate, or 4 cwt. of basic slag—the latter where the land is in need of lime—will quickly improve the poorest grass fields, and, as year succeeds year, convert land which is almost barren into a comparatively luxuriant pasture or meadow. For ordinary purposes, meadow land in fairly good condition may be maintained by the annual application of 1 cwt. of nitrate of soda with 3 cwt. of superphosphate, or 5 cwt. of basic slag.



TRIANGULAR FORM OF THORN HEDGE

A pasture is not so easily exhausted as a meadow from which the crop is annually removed, and for this reason it is seldom manured. Grazing promotes the growth of the finer grasses, and the diminution of those of a coarser nature. The best pastures are in the lowlands, especially in river valleys, on rich marshes and alluvial soils ; and here it is customary to feed off the crops with cattle. On the other hand, the poorer pastures are on the uplands, of which the downs are an example, and here sheep are employed with the same object ; but it is seldom that we hear of either upland or lowland pastures being manured with dung or artificials. Owing to the shortness of the roots of the grasses and their consequently diminished power of extracting mineral foods, it is essential that, from time to time, the chief mineral fertilisers, potash and the phosphates, should be supplied if the land is to produce good crops. If nitrogenous manure is employed, the grasses will respond to it, but at the expense of the clovers, which are of high value as food, unless phosphatic manure forms part of the dressing.

To Get the Best from Land. Although the average British hay crop is only 23·6 cwt., and the average English crop 24 cwt., a 1½-ton crop corresponding to 5 tons of grass, it must not be supposed that it is impossible to exceed this quantity on soil of average quality. It is customary among farmers to depreciate the value of the land they occupy ; but there is very little land in this country which is farmed for a livelihood which could not be immensely improved and which would not grow much larger crops by good management.

What do we mean by this term ? Simply, that the grass must be fed with manure, the fields in which it grows kept in rational condition, the drains kept open, the ditches cleaned out, the fences maintained, and the most obnoxious weeds permanently removed—we refer in chief to such as the thistle and the dock, for time and manure alone will cause a suppression of weeds of a less marked character. In the early spring grass-land needs harrowing, by which means moss is pulled up, the soil ærated, embedded stones brought to the surface for picking, the droppings of cattle spread, and the land prepared for broadcasting artificial manure. Before rolling—a very necessary operation, for grasses like a solid bed—stones must be picked up and carted away, and mole-hills and anthills levelled. A field is then ready for the scythe as soon as the crop is grown.

Irrigation. Grass-land is occasionally irrigated and maintained as a water-meadow, but the cost of preparation is considerable, hence the system is unpopular. Under a normal system of irrigation the water is turned on to the land, over which it runs through channels made for the purpose during late autumn and winter, when, owing in part to the fact that the water is moving, and in part to the further fact that it is charged with oxygen, the grass is induced to grow during cold weather. In spring the water is turned off, preparatory to the growth and harvesting of the crop, after which the land is again irrigated, that a second growth may be encouraged for feeding stock in autumn. A student of grass and hay production will learn much by inspecting a well-managed system of water-meadows, which he may be able to apply to his own farm should it be situated in such a position that irrigation may be possible.

Laying down Land to Grass. Many of our permanent pastures have been under grass from prehistoric times. Grass-land, however, is frequently ploughed up and planted with arable crops; but it is provided in most leases and agreements that the ploughing of permanent pasture is at the peril of the tenant, who is heavily penalised. It is much more common, however, to lay land down to permanent pasture, although some years must elapse before it can be regarded as first-rate, however well the work may be managed. Preferably the crop in the previous year should be roots or potatoes. An opportunity is thus given for both cleaning and manuring the land. If the root crop consists of turnips, it may be fed off by sheep which are well supplied with cake and corn. In this way the droppings will further enrich the land and still better prepare it for nourishing the young grass plants in the following year. In some cases land intended for grass is bare-fallowed—*i.e.*, it is cleaned, and no crop is grown.

In all cases success depends upon the cleanliness of the land, sufficiently deep ploughing, fine tilth, a firm bed, and good seed. Care should be taken, especially where sheep feed off a turnip crop, that the manure they have dropped should be kept near the surface, so that deep ploughing should have preceded the sowing of the turnips, while subsequent ploughing should be shallow. This will ensure a firm and yet sufficiently fine seed-bed. The surface cannot be too fine, nor, subsequent to seeding, too compact. Many experienced farmers prefer to sow grass and clover seeds for permanent pasture in a wheat crop, especially for the reason that, owing to the lapse of months since the wheat was sown, the bed will be firm. If, before sowing, the wheat is hand-hoed—although this is a costly operation—and subsequently harrowed in fine weather for the destruction of small weed plants, a grass seed-bed will be prepared. The seed may be sown with the barrow, as elsewhere described, covered in with very light harrows, and subsequently rolled to complete the process.

It is probable, however, that the majority of skilled farmers sow their grass seeds in spring corn—barley or oats; but whatever the practice, the suppression of weeds, the provision of fine surface tilth, and a compact seed-bed, are imperative. It is obvious that the seeds should not only be of high germinating power, but of great purity. In the chapter on grasses will be found suggestions for seed mixtures. The seed should be sown and the whole operation completed in fine weather, tramping on a grass seed-bed in wet weather, especially if the soil is heavy, being disastrous.

Continued

ROME, THE PARAMOUNT POWER

The Punic Wars. Hannibal. Invasion of Carthage. Roman Progress. The Gracchi. The Rivalry between Sulla and Marius

Group 15
HISTORY
10

Continued from page 1204

By JUSTIN McCARTHY

HANNIBAL had another great encounter with the Roman army at Cannæ; and, with comparatively little loss to himself, he so completely conquered the forces of Rome that after a while the battle became a mere slaughter of the Roman soldiery. This proved the turning-point in his career. The Romans, though defeated in three battles, had still ample resources, and their defeats only filled them with greater resolution, and made it the patriotic duty of every Roman to help his country, at any personal sacrifice, to recover her ascendancy on the field.

Hannibal. Hannibal understood the situation quite well. He knew that the Romans could create army after army to maintain their power in Italy, and he called upon his own countrymen to sustain him with the needed supplies. The Carthaginians, who had little natural inclination for war, began to grow tired of the demands made on them for reinforcements. Although he never wasted his means or his men, Hannibal soon found that by no effort on his part could he hope to carry on the war under the limited conditions his countrymen were imposing on him. He spent a winter in Capua, which, although an Italian city, said to have been founded or colonised by the Etruscans, had gone over to Hannibal's side after the battle of Cannæ. Capua was then especially famous for its riches and its extravagant luxury, and the legend passed into history that in the delights of that winter refuge the soldiers of Hannibal, and even Hannibal himself, became enervated by a manner of living previously unknown to their frugal habits.

To this day Capua remains a synonym for idleness and luxury, and the commonly accepted legend is that Hannibal and all his forces never recovered their strength after that Capuan winter. There seems no reason to believe that any such effect was produced upon the General or those who bore arms under his command, for Hannibal subsequently gained many victories over Roman armies. It is quite certain that the interval of rest at Capua had a decided effect upon the Romans and the Carthaginians alike.

A Change of Tactics. The Romans began to find that they had made a great mistake in their plan of military operations, that they had undervalued the genius of Hannibal as a commander and the strength of the army which acted under his direction. It became clear to them that by opposing in the open field successive great armies to the army of Hannibal they were giving to the invader the best possible chance of succeeding in his project. Such a course of action deprived them of all the advantages they might have had from the physical difficulties which the country offered to the progress of the invader. They found that only by sudden surprises, by keeping always in the field a large number of comparatively small armies, strong enough to make his progress impossible through regions where the mountains hemmed him in here and there, and by thus thwarting every move he might attempt, could they render his final success impossible. "In one small path a thousand might well be stopped by three," says a hero in Macaulay's "Lays of Ancient Rome." The Roman leaders of Hannibal's day prepared to act on these principles, and to bring up forces enough to stay his progress in every difficult way.

Hasdrubal. Hannibal began to see that the resources of the Romans were far greater than he had supposed them, and that the moment one Roman army was defeated, with whatever amount of loss, another Roman army as large, or larger, was soon in the field. He found also that many of the Italian States which had been subdued by Rome were now rallying to her side against the foreign invasion, and were daily rendering his ultimate success more and more difficult. His military strength was becoming gradually diminished, and his own people at home seemed little inclined to continue to send him men and supplies enough to give him any hope of ultimate victory. He was expecting with intense anxiety the arrival of his brother Hasdrubal in the north of Italy. Hasdrubal, who was a brilliant soldier, succeeded in crossing the Alps and marching into Italy in order to come to Hannibal's aid; but he was defeated by the Romans, his army was almost cut to pieces, and he met his death in the battle.

An Interval. This event practically put an end to all chance of Hannibal's success in his tremendous undertaking. He appears now to have given up for the time all hope of offensive operations, and his only purpose was to maintain himself in a mountainous region, and there await the possibility of events. The fact that he was enabled to hold his ground for nearly four years proves how much the military strength of Rome must have been diminished by so many battles. But Hannibal knew well that the interval of comparative cessation from great military operations on both sides was only giving to the Romans all the better opportunity for organising new armies, and marshalling them to the defence of their country.

The Romans were now preparing to turn the tide of war by the invasion of Carthage, and Hannibal had to cross over to Africa in order to take the lead in resisting this new enterprise. A great battle was fought at Zama, between Tunis and Algeria, in North Africa. The Roman army was commanded by Publius Scipio, one of the most brilliant Roman generals of his time. The Carthaginian army was completely defeated, and Hannibal himself only escaped with a fragment of his forces. The struggle was now practically over, and Carthage appeared to be almost at the mercy of the invaders. So complete a turn in the fortunes of a great war is not often recorded in military history. Hannibal appears to have risen at once to a full comprehension of the actual condition of things, and he was earnest in his endeavours to bring about terms of peace between the Romans and his own people.

The Destruction of Carthage. The leaders of the opposing States on both sides were probably alike anxious to bring this long war to an end. Scipio, when he returned to Rome, received all the honours which the State could give to such a conqueror. To his name of Publius Scipio was added that of Africanus, in honour of his African triumph. The destruction of Carthage was practically accomplished, and its inhabitants had already been compelled to abandon their capital city and settle where best they could several miles inland. Thus was realised the declaration of Cato the Censor, the celebrated soldier and scholar, who had been one of the Roman deputies sent to Africa to assist in the final treaty between Rome and Carthage—the declaration often repeated by him that Carthage must be destroyed, *Delenda est Carthago*. Thenceforward the whole Carthaginian region became a province of Rome. The city itself remained a ruin for more than 30 years, and then was restored as merely the capital of a newly created Roman colony. It had still some position in history, and will have to be mentioned again at a later period.

Roman Progress. Rome was now called the ruling Power of the Western world. She ruled over Spain and Greece, as well as Italy. Her power extended from the Spanish coast into the heart of Asia Minor. She was making distinct and rapid progress in political affairs and in civil life generally, as well as in the business of war. The effect, however, of her recent conquests upon the condition of her internal affairs was in many ways just that which invasion and conquest commonly produce on the home life of the ruling nation. Luxury and extravagance of all kinds were fast banishing the simplicity and the moderation of former days, and were beginning to threaten the liberty of the people and the principles of the Roman constitution. The adventurer who had made money by the pillage of subdued peoples was becoming a power and a subject of imitation and emulation at home, and even when he held no place in the State was often able to exercise a most pernicious influence over public affairs. Certain families became possessed of enormous wealth, while the humbler orders of the people were growing poorer.

Then arose some great reformers. Two of these—the Gracchi—will ever be renowned in history. These brothers were the sons of the celebrated Cornelia, daughter of Scipio Africanus, one of the most gifted and accomplished women of her time—a pattern of domestic virtue, who had watched with untiring care over the education of her two sons, whom she was destined to survive. Tiberius Gracchus, the elder of her living sons—she had many other children, all of whom died at an early age—was deeply impressed by the condition of the poorer population in Rome. He saw how the condition of the State was rapidly degenerating. He saw that reform in the conditions of holding land must be the first measure of improvement in the condition of the poor.

Proposed Redistribution of Land. Rome had of late come to possess a vast territorial property, but the land had been practically appropriated by the nobles and by those men who, belonging originally to the poorer classes, had contrived to enrich themselves in war and by war speculations. The policy of Tiberius Gracchus was that the State should once again take possession of all the lands thus appropriated, and divide them anew in such a manner as to enable the poorest men in the State to have some share, however small, of these Roman possessions. There was already actually in existence a public law which forbade any individual to possess any more than 500 acres of public land, the Roman acre being only about half the extent of the acre according to modern English measurement. That law, however, had been entirely neglected during the rush for land among the Patricians, when recent invasions and conquests had given them opportunity for such a contest. Tiberius Gracchus, while proposing to re-divide the national landed property, proposed also to pay an indemnity to deprived landlords for any money actually expended by them in the improvement of the land. These reforms were fiercely resisted by the Patricians and all their supporters and dependents. Fierce riots were the result of this contest, and Tiberius Gracchus was killed on the very steps of the Capitol.

The Mantle of Tiberius Gracchus. Then came the public career of his brother, Caius Gracchus. He was elected Tribune, and he adopted his brother's plans of reform and did his best to carry them out. Indeed, he did not merely his best to realise all the reforms which his brother had undertaken, but went even farther in the same direction ; and his influence was so great with the people that for him to propose a measure was to secure its success by the popular vote. He succeeded in depriving the Senate of some of the exclusive privileges which they held most dear, and accomplished many important alterations in the judicial system of the State, tending to make the administration of the public laws less of a monopoly in the hands of the Patrician order.

He was elected Tribune for the second time, and then the Senate endeavoured to put into execution a rather ingenious plan, or rather a plot, for the undermining of his influence with the people. They prevailed upon one of his colleagues in the Tribuneship—it was commonly believed by rewards and other corrupt means—to propose measures of reform far more extreme and revolutionary than Caius Gracchus, with his statesmanlike judgment and desire for the common good, had ever thought of adopting or recommending. There was at that time arising from the influence of the Gracchi themselves a thirst among the people for revolution rather than reform, and among those who had hitherto strenuously supported the measures of Caius Gracchus was a considerable proportion of men who began to regard their former leader as behind the age in his political reforms. The immediate result of this secession was that Caius Gracchus failed to secure his election as Tribune for a third term. As soon as this had been accomplished, and when, under the influence of the secession, the Patrician order had obtained a more submissive personage to hold his place, the Senate began to work for the repeal of some of the reforms which he had succeeded in carrying into law.

Reaction. Caius Gracchus was not the man to put up with these attempts, and he presented himself publicly in the Forum to oppose and denounce the schemes of his enemies. The Forum was crowded, and a furious riot took place, in which the supporters of the Patrician order were again able to win the day. Some 3,000 of Gracchus's supporters were killed in the fight, and Gracchus himself was compelled to fly for refuge to a neighbouring grove, a grove which, ominously enough, had been dedicated to the Furies. There, seeing no hope before him, he took counsel of despair. He had with him as his sole companion a devoted slave, whom he ordered to kill him. The slave obeyed, and having killed his master, then killed himself. A reaction in the popular feeling against Caius Gracchus soon set in when the news went abroad that the once popular Tribune was dead. The Plebeians broke out into renewed admiration of their former advocate and hero, and endeavoured to show their contrition by raising statues to both the brothers. The mother of the two Tribunes long outlived her sons, and when she died had her tomb inscribed with the words: "Cornelia, mother of the Gracchi."

"The last of the Gracchi," said Mirabeau, the great Tribune of modern days, "when dying flung dust towards heaven, and from that dust sprung Marius." Marius seemed, indeed, as if he had come into the world to avenge on the Roman Patricians, and on those who supported them, the wrongs done to Tiberius and Caius Gracchus. Marius was a man of humble origin, born of a poor family in a provincial village. He was brought up with little or no education, but he began early to show his great capacity as a soldier, and served with distinction in many battles. He soon proved that he had a much higher military genius than was necessary for a commou soldier, and that Nature had intended him for a great commander in the ordering of war.

Marius. It became known to the general public that his political sympathies went much with the suffering Plebeian order, and he was elected Tribune of the people. He still, however, carried on his military work, and served in Africa during the war against Jugurtha, King of Numidia, in North Africa; and, indeed, Marius was mainly instrumental in bringing that war to a close, after which Numidia became a subject country or province of Rome. Marius in his civil capacity endeavoured to introduce certain levelling acts of legislation which greatly angered the Patricians. As generally happens in such a career, he did not go far enough in his levelling policy to satisfy all the demands of those who were following him and urging him forward. On the other hand, he conciliated to a certain extent the favour of the Patricians by a marriage with a woman of their own order. He became the husband of the Patrician Julia, grand-aunt of Julius Cæsar.

Tribal Wars. New wars broke out with some of the Teuton races, and the Cimbri who had settled in the Peninsula, a narrow strip of land running between Hellespont and the Gulf of Melas, a river of Thrace. These tribes were making frequent invasions into Gaul, then regarded as a province of Rome, and they actually defeated five Roman armies. Marius was then in Africa, but Rome summoned him back to undertake the work needed for the defence of the Republic. Marius hastened to Italy, and prepared to encounter the Cimbri. He was completely victorious over Cimbri and Teuton alike, and the carnage amongst the defeated combatants appears to have been something like a massacre.

Marius returned to Rome with all the pride of his later victories to stimulate him. His ambition was not satisfied, although he was appointed to the office of Consul for several successive years, not because he was occupied in consular duties, but merely as a reward for his services in war. There was a new struggle between Marius and the Patricians, and the Patricians adopted as their candidate a well-known personal enemy of his. Marius had by this time become the hero and the idol of the people. He was popularly proclaimed as the saviour of the State, and hailed as the third founder of Rome. He was made Consul for the sixth time.

Sulla. But a rival was now arising, a man destined to leave his imprint on the history of Rome. This was Lucius Cornelius Sulla, who belonged to a Patrician family. He had had a good education, possessed a strong love of literature and art, and had been a close student of the literature of Greece as well as that of his own country. Like most young Patricians, he entered upon a military career; he served under Marius in Africa, and showed from the first a remarkable capacity for success in the field. He was a man of strong ambition, and it has to be added that his life all through was much darkened by sensuality and even debauchery. He took service under Marius in the wars between the Romans and their enemies the Cimbri and the Teutons; and in these wars, which spread over a period of more than two years, he won for himself so great a reputation that Marius soon became jealous of his fame. Disputes arose between them, and Sulla ceased to serve under the commander within whose ranks he had risen so high. He accepted a position in the forces led by another general, and after a while obtained the chief position in that army for himself.

Rivalry between Sulla and Marius. After the return of Sulla to Rome the rivalry between him and Marius began to make itself more distinct and dangerous. The Patricians took him up eagerly, partly because he belonged to their order and partly because his talents and his celebrity seemed to mark him out as a powerful champion of their cause in the political struggle then going on. New wars broke out in foreign countries; Sulla had many opportunities of winning success as a commander, and the greater his success in the field the greater became the admiration displayed for him by the Patrician order. Marius was now no longer young, and his rival had all the advantage of comparative youth. The struggle between the orders soon became a civil war, and at first the tide of fortune set in wholly against Marius, who had to fly from Rome. He found refuge, after many dangers, by making his way into Africa.

In the meantime the friends and followers of Marius in Rome were not idle, but made every preparation for his restoration to his former place as the leader of the popular order. His most active and powerful friend in Rome, Lucius Cornelius Cinna, exerted himself to the uttermost for the complete overthrow of the Senate and the Patricians, and for the recall of Marius to Rome. These efforts were defeated at first, and Cinna had, for a time, to leave the city; but he soon returned and organised a popular rising in support of his plans. Marius came back to Italy, and, in co-operation with Cinna, led an invading army against Rome. The city had to yield under the sudden pressure, and Marius had now ample opportunity for satiating his revenge upon the aristocratic order. He behaved as, even in those wild days of warfare, no foreign and conquering invader would have done. During the greater part of a week he employed his slaves—not his soldiers—in a massacre of the Patricians in Rome. Now, indeed, it would seem as if the handful of dust thrown up towards heaven by the last of the dying Gracchi had wrought its full vengeance in the success of Marius over the Patrician order. The success, however, did not last very long, and Marius died soon after.

Sulla's Triumph. But Sulla was yet to come. He entered Rome in triumph and utterly crushed for the time the followers of Marius. Later he won victories over foreign enemies also, returned to Italy, and became master of Rome. The State was now thoroughly weary of the civil struggles which had been going on so long, and seemed, above all things, to yearn for an absolute master. Sulla was created Dictator, supreme ruler of the State. And then followed a period of proscriptions, a real reign of terror. He crushed his enemies without remorse. During his rule some great reactionary changes were accomplished by his authority, all having for their object to restore, and even to enlarge, the power of the Senate and Patricians.

Sulla's supreme position induced him to indulge to the full all his love of sensual excesses; he wore out his physical strength in revelry and debauchery, and died soon after while still in his prime. He had hardly been laid in his grave before the preparations began for new constitutional changes and for the resurrection of the democracy. It will be seen that during all this period every chance for the establishment of some settled form of constitutional government, with legal equality for all classes and the maintenance of civil union, had been blighted by the unceasing succession of wars against other Italian States and against foreign rulers. Even if there had been great and enlightened patriots at home to carry out the much needed changes, it would have been hardly possible for such men to accomplish their peaceful revolution while the State was still distracted by these foreign enterprises and civil wars.

The Coming Man. The tendency of things seemed to point to the necessity of some man arising who could make himself for the time supreme master of the whole government of Rome. The people were becoming weary of the incessant strife at home and abroad, and especially of the continual struggles between this faction and that to obtain the mastery over the Roman people.

They were beginning to feel that they could gladly welcome the rise of any Power, even of an Imperial Power, which could promise them a quiet and steady existence, and allow them to carry on their ordinary daily lives in peace, without the exaction of enormous taxes for the maintenance of armies, the reckless waste of public money, and the ruin of civic interests in the struggles of rival orders. Kings had been tried; consuls had been tried; tribunes had been tried, and nothing thus far had been established—for a change in the form of government does not necessarily carry with it any actual change in the political conditions of the State.

All the provincial States of Rome, the States not actually Roman by population and by race, were feeling keenly the exactions and oppressions imposed upon them by war, and were sometimes willing to join even a foreign enemy in the hope of obtaining better conditions for themselves. The time seemed specially adapted for the experiment of a dictatorship in the person of some man who had proved himself equal to a resolute effort at the remoulding of Rome's political condition, and who would not depend for his position or his opportunity on the support of one or the other order, one or other faction, in the Roman Republic. That man was then living, and was destined before long to take his place. The hour was soon to come, and the man.

Continued

FLAX, HEMP, JUTE, & RAMIE

The Preliminary Processes of Manufacture. Pulling, Retting, Sorting, Scutching, Roughing, Hackling, Softening, and Filling

Continued from page 1347

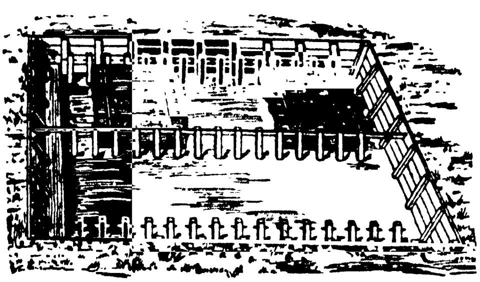
By W. S. MURPHY

FLAX

Some of the earlier operations in the treatment of stem fibres are agricultural rather than manufacturing; but the principles of the industry run through from start to finish.

Pulling. When the flax stems have yellowed half-way down the stalk, then is the time to begin pulling. Hand labour is employed, though no great skill is required. It must not be understood, however, that flax may be pulled anyhow. In this, as in most operations, there is a right method, and a great many wrong ones. Flax stems grow closely and evenly together, therefore the skilled worker can take a handful and pull them out by the root. Wrenching will not do; the pull must be straight and clean, taking no more of the soil than clings naturally to the root tendrils. Giving the roots a shake, the stems are laid evenly down along the row. Bruising or breaking of the stems must be avoided. As a rule, the pullers are followed by the "beeters," who shake the roots thoroughly clean from adhering soil, and lay the stems out in sheaves or "beets," putting those of equal length together, the root ends even. Then the sheaves are taken up and the flax made into bundles.

The seed is seldom gathered, either in Ireland or this country, but, if it be considered worth while, is secured by a kind of hackling, called *rippling*. On the end of a plank a row of tall spikes is fixed, and the plank is fastened on two supports. With the sheaves laid in order by the side of the plank, the man gets astride, and pulls handful by handful through the comb of spikes, rippling off the seeds.



50. FLAX RETTING PIT

Retting. Here we come to the trouble which always faces us whenever we want to use a bast or a stem fibre. Naturally, the fibres hold on to the wood or vegetation they were born to support; but the substances so important to the fibres are a nuisance to us, and they must be got rid of. We shall see many methods, but the general plan adopted for winning the flax fibre from its woody core is *retting*, more scientifically termed fermentation. Two methods of retting are practised, the one the field and the other the factory method. First, we shall take the field retting, practised universally from beyond the beginning of history up till about fifty years ago.

Retting Pits. Dig shallow, square pits [**50**], with slanting sides; lay the bundles of flax, root downward, in the pits, sloping them to the four sides. When each pit is full, pour in as much pure, soft water as the pit will hold, cover over with a layer of stiff rushes or straw, and over that put a solid roof of turf; then hold all down with heavy stones. Fermentation quickly sets in, decomposing the woody fibres. As this action is very powerful and by its nature destructive of all tissue, it needs to be carefully watched, and, from the effluvia arising, the duty is not a very agreeable one.

When the woody boon slips easily from the fibre, the fermentation has gone far enough, and the pits may be opened. Lift off the coverings. One man usually stands inside the pit, takes hold of a bundle, rinses it clean in the water, and hands it up to his partner, who sets each sheaf up, as he receives it, into position for draining, preparatory for the next process.

Factory Retting. The factory method of retting is not yet largely adopted. From among the several processes, we would select that of retting by steam heat as seeming to offer the best basis for development. When brought in from the fields, the flax stems are run through a breaking machine or softener [**51**], consisting of a series of fluted rollers, in which the stems are crushed loosely, so as to bruise, but not to cut the fibres. Thus loosened, the stems are put into shallow iron vats, on the bottoms of which are coils of steam-pipes. Having been packed with fibre, the vats are filled with water, the lids of the vats are closed, and steam sent into the coils of piping in each vat. Fermentation is thus set up, and rapidly brought to a height. The action is also easily controlled. When sufficiently retted, the stems are taken from the vats.

Grassing. Whatever process of retting be used, the fibres must be aired and partially bleached by what is fitly termed *grassing*. The sheaves are thinly spread out on the grass, and left exposed to the sun and air, being sweetened and freshened in the process. After due exposure, the sheaves are gathered again, the roots being all at one end and made even.

Scutching. Here we have an example of one term used to signify very different things. Scutching cotton is a very different process from scutching flax, and comes in the opposite order. Cotton scutching is the last of a series of preparing operations, baling, opening, and blending having come before; flax scutching is the first mechanical operation, if we follow the field method of retting. Yet the main act of both operations is the same. The old name of cotton scutching was batting, and the Egyptians scutched flax by batting or beating. Further, the scutching beater, working inside the cotton scutching machine, is just a miniature of our flax buffer, or beater. The real explanation is, that while the former has become complex and applied to refined purposes, the latter has remained simple.

51. HEMP OR FLAX SOFTENER

Scutching is really two operations. First, there is the breaker or softener, and then the scutcher. But the breaker need not detain us long. It is simply the set of fluted rollers already seen in the factory method of retting. The sole difference here is that the breaking is done more thoroughly. We pass the root end of the handful of flax through, bring it back and send the top end through, softening and breaking away the fibres from the whole length of the stem.

The Scutching Machine. Now we come to the scutching machine. Seen standing still, it seems a primitive contrivance. On a spindle geared to high speed, five arms are fixed, like the spokes of a wheel, and on the end of each arm projects a flat blade of hard wood. In front of the beater, and nearest the worker, is an iron stock, standing upright. The method of operating is equally simple, though not altogether without an element of danger and difficulty, calling for some skill. You take a handful of flax, and put on the drive. Thrust the flax in, root end first, over the stock and within touch of the beaters, letting the stems go in as the beaters draw, till a little beyond the middle of the length, then pull out, reverse the stems, and scutch the other end in the same way. Our handful is named a finger; but after the flax has been scutched, it has to be divided into quantities called stricks, each weighing about a third of a pound, and made up into parcels of 14 lb. In this form the flax cultivator sends the fibre to the market, and sells it to the spinner.

Cutting. When we open out a stone of fine flax, the first thing to be done is rough sorting. This is chiefly done as preliminary to cutting and ranging the fibre into handfuls, or "pieces," for the cutter. The *cutting machine* is a blunt circular saw, with a pair of grooved pulleys on each side. We feed the flax into the pulleys, so that the saw will cut off about a third of the length from the root. The saw runs at high speed, and the pulleys revolve slowly carrying the fibres against the blunt teeth of the saw. The root end is laid aside, and the remaining part is halved. We thus have three lengths of flax—the coarse and strong root ends, the fine and strong middle, and finer, but weaker, tops. Separately bundled in stricks, these pieces are ready for further operations. We leave them aside, meanwhile, however, because the great mass of the flax is not cut. Only the very highest class is dealt with in this way; hand-scutched, Riga, and most home-grown qualities, go directly to the first hackling, or *roughing*, as it is called.

Roughing. Because this work has never been highly paid, the outside public have imagined that it is not much of a craft. No greater injustice could be done to any class of industrious workers. Many persons enjoying high salaries in more favoured trades would make very poor roughers. Deftness of hand, quickness of eye, and flexibility of muscles are called for at the work. The tool of the rougher is a strong hackling comb, consisting of a tin-sheathed stock ¾ in. thick, into which are set strong steel spikes, 7 in. long, tapering to a fine point. Screwed into a board, larger all ways than itself, the comb is fixed to the end of the workman's bench in a slanting position, the points leaning away from the rougher. Opening out the bundle of flax, we take a portion between finger and thumb, flatten it out, and even the ends on the bench. In this way, a "finger" is formed, the quantity being so named because it is as much as will lie comfortably on the fore-finger, and between it and the thumb. Grip firmly by the top end, whip behind, like the lashing of a whip, to open

out the fibres, then bring down on the comb, and pull through.

Easy as the action seems, described in this way, much practice is needed before dexterity is acquired. In addition, the rougher is required to exercise his judgment as to the exact amount of work the flax will stand. Beginning near the end, the flax is thrown farther and farther into the comb, till near the hand; then shift, bringing the top end to the comb, and work it through in the same way. When satisfied that the fibres have been combed out clear of dirt and rubbish, square the root ends on the touch pin at the side, give the bunch a twist over, and lay on the side of the bench. As roughing is usually piecework, quickness is a quality almost indispensable. Clear the tow from the teeth of your hackle and begin again.

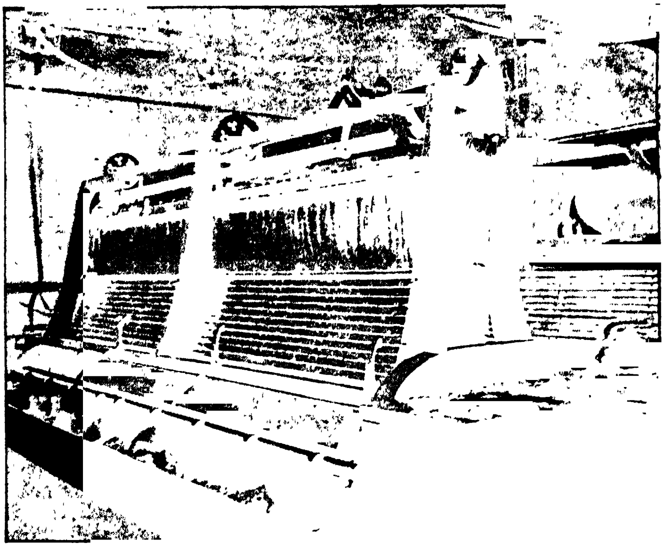
Hand Hackling. There are various reasons for hackling by hand, even in factories equipped with the very best machinery. The logic of the market drives even the proudest of old-established firms into new methods. Perhaps the best and most potent reason for the continued practice of hand hackling is the fact that for fine and special work the hand worker produces better results than the machine.

The first comb used by the hackler, as distinguished from the rougher, is the "common eight." In this comb the teeth are finer, shorter, and closer together. But the mode of operation is quite different. Both hands are employed. Having selected the batch, lay the top on the backboard of the hackle and hold with the left hand; with the right draw down the fibres into the comb and pull through. Repeated till the flax is hackled, this operation must be carefully done. Nothing is more common than for the novice to find all his fibre gone to tow—that is, he has hackled all his flax away, and his whole bunch is in the teeth of the hackle. But the expert knows just how deeply to let the fibre into the grip of the steel teeth, and what force to put into his pull. For fine yarn, the process of hackling is carried much further. The "fine eight" is considered the ordinary finisher, but the "ten," the "twelve," and the "eighteen" may be called into requisition. As the art of the hackler is practical, and dependent more on the ability of the individual worker than on anything else, directions are not of much use. The object in hackling is to retain all the long fibres and comb out the short fibres. An expert hackler will bring out a splendid tress of flax, cleared of tow, not having lost a single long fibre. The fibre adhering to the hackling comb is called **"tow," and the long fibres which survive the ordeal are named "line." Tow and line part at this point, to be separately treated and made into yarn—perhaps to rejoin again, the former as weft and the latter as warp in the linen. We enter more deeply into that matter when we deal with the far larger quantities of both kinds of fibre which come from the hackling machines.**

Machine Hackling. Our object in hackling has been sufficiently indicated by the hand operation; we can therefore proceed directly to the machine itself. It may be said that there are several kinds of machines; but the principle of all is the same, and, by taking the most important and complex, we include the others, saving the student a good deal of wearisome technicality. In general structure the hackling machine is a square iron frame, under the top beams of which hangs a railed bar, geared to move up and down and to and fro. In the centre are two endless bands, carrying iron bars studded with spikes, strong and wide apart at one end and becoming finer and closer set towards the other end; underneath, a set of brush rollers; and, in front, a long trough, extending across the whole machine.

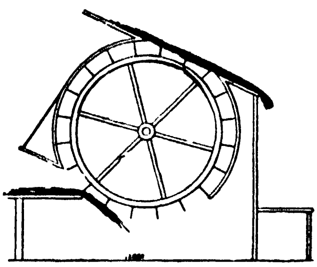
By observing this machine [**52**] in operation, we may better understand the details of its construction.

The railed bar we noted on the head of the machine is the holder channel, and on it are set the holders—double plates of iron, 11 in. by 4 in., and held together by bolts and screws. These are taken down by the "filler" boy, and laid on his bench. He has the stricks of flax, as they came from the rougher, and, unscrewing the plates of a holder, he lays one strick and then another, spread flat, on each side of the bolt. Having done this, he lays the other



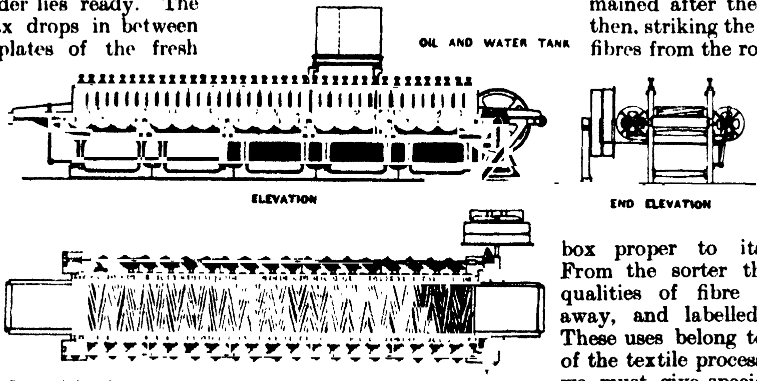
52. BRUSH AND DOFFER HACKLING MACHINE
(Stephen Cotton & Co., Belfast)

plate on top and screws them firmly together. Corrugated indiarubber lines the insides of the plates, to give them a firm hold of the flax. In this way the lad fills all the holders, and then places them on the holder channel in the machine. The fibres now hang, root ends downwards, like tresses of coarse hair. We are ready, and the machine starts. The motion of the long, horizontal hackling bars is always up on the outer side and down on the inner or centre side. The holder channel always brings the tresses of flax down the centre, between the hackling bars, and lifts them up again, at every lift sending the holder a stage along nearer the end of the machine. We have thus a double combing motion, the endless bands of hackling bars pulling down and the holder channel drawing up. As the hackling bars emerge from action, their teeth are cleared from tow by the doffing brushes, from which another brush or doffing comb brings the tow into the trough at the foot of the machine. Some machines are doffed by bar-strippers alone, or by combined brush and bar doffing apparatus.



53. HEMP SCUTCHER

When a holder has run the full course, the slide rack projects it outside the channel, and the attendant lifts it off, and lays it on a bed, within which another holder lies ready. The pendant flax drops in between the open plates of the fresh holders, and is loosened from those in which it has been hackled, the unhackled portion being thus exposed. This new holder is screwed tight, set in the channel, and the top end of the flax is hackled. Great care is required in the setting and working of the hackling machines. The endless band of hackling bars is stretched between two rollers—the lower one supplying the driving power and the upper one acting merely as support and carrier. If the hackling pins are to be efficient, they must intersect, the one set with the other. The measure of intersection depends on the thickness of the fibre, and the weight of the hackling bars in motion tends to make them sag and fall out of plumb. For these reasons the upper rollers are adjustable, the tightening of the bands and the degree of intersection being regulated by means of power-screws set in the iron frame and working on the sockets of the rollers.



By permission of 54. JUTE SOFTENER *Mr. Wm. Kidd, Dundee*

Sorting. Hackled flax has a very fine appearance, the long, silvery, or yellowish tresses closely resembling silk in their sheen. Of course, a touch dispels the illusion, for the fibres, though soft, have not the smooth flexibility of the finer material. In this condition the flax comes to the sorters. Here, once more, the essentially primitive character of flax manufacture asserts itself. Sorting is a skilled craft, to be acquired only by practical experience under the tuition of a good workman, and by the cultivation of fine sight and touch. Let us enter into the spirit of the sorter at his bench. On the bench are placed in order a row of boxes, labelled 2 lb., 3 lb., 3½ lb., 4 lb., and so on, according to the old system, by which fineness was denominated by weight, not unlike in principle our method of determining the counts of yarn. At the side of the bench stand two hackle blocks, one coarse and one fine, the latter being named the *switch*. From the ranged fibres the sorter selects a lock of flax, and deftly separates it with his fingers, touch helping him to determine exactly the degree of fineness. With a quick motion he draws the fibres through the hackling blocks, one after the other, straightening out the slight tangling which may have remained after the hackling; then, striking the projecting fibres from the root ends to make them square, he throws the "line," as we must now name it, into the box proper to its quality. From the sorter the various qualities of fibre are taken away, and labelled for use. These uses belong to a section of the textile process to which we must give special and detailed study.

DRESSING HEMPS

Common Hemp. In the competition among the various fibres for the textile market, hemp has not been without faithful and ardent supporters. Hemp, say they, is among the neglected fibres; there are possibilities in it which have not been utilised. At present the fibre is treated as a kind of inferior flax by most manufacturers, and this is objected to by the partisans of hemp. After due consideration, however, of all that has been put forward in favour of hemp, we are bound to conclude that the practical judgment which places hemp in a midway position between flax and jute remains justified. It may be admitted that hemp yields a longer and more uniform staple than flax; but the advantage of a very long staple, with our present methods of spinning, is more than doubtful.

We certainly welcome the rivalry of fibres for favour at the hands of the textile trade, because, whoever loses, the industry must benefit. For example, we understand that the method of retting already described as the indoor or factory method was first adopted by users of hemp. In practical fact, with only slight differences in nomenclature, the processes of hemp and flax manufacture are identical. The student, however, must always be on the alert, and be ready to observe any improvements which may be introduced into either process. It is quite conceivable that the flax manufacturer might find hemp taking hold of his market, because, by an improved process, the hemp worker had so softened and refined his fibre as to claim the premier position.

Manilla Hemp. The preparation of Manilla hemp is mostly done in the country where it is grown, by native labour, and by hand. It arrives in this country in bales of heavy fibre. The lower qualities are hackled and scutched, but the higher grades are passed directly on to the spreader, or carder. At our present stage of study, therefore, we have little to do with Manilla hemp, beyond seeing it opened out of the bales, the good separated from the bad or damaged, the latter sent to be treated along with coarse flax or hemp, and the former shaken out and sorted for the carders.

Sisal Hemp. Like Manilla, this hemp is brought into the state at which it can be dealt with by the carder before it leaves its country of origin. But there are circumstances which impart a special interest to the early preparatory processes of sisal. As already shown, sisal is derived from a fleshy leaf, the fibres being under a soft skin, which must be peeled off. So long as there was no great demand for the fibre, the slow process of hand decortication was accepted as the best possible, but the huge demands of the American farmers for a cheap binder twine caused enterprising manufacturers to look out for quicker methods. Previously, barley in this country, and hominy in America, had been decorticated, or husked, by a kind of iron grater device, and the hint was taken up and improved upon, with the result that a mechanical decorticator was contrived. As seen on the plantations at Yucatan, the decorticator [55] is a huge, clumsy structure, but it embodies the root principle. Into this curious combination of drums and wheels, the *pencas*, or leaves, are fed, to issue at the other side in streams of fibres. The leaves are stripped by knives with turned edges in an endless band. Whatever may be the defects of this machine, it has certainly shown, in a practical fashion, that the problem presented by the mechanical decortication of long fibres is soluble.

Having thus been made into a clean fibre, sisal is ready for the carder.

New Zealand Flax. This fibre is very long and coarse, and requires to be put into the teaser, a machine similar in structure to the wool teaser. When reduced to manageable proportions, the fibre is passed through the same treatment as flax.

55. FIBRE COMING FROM THE DECORTICATOR

JUTE

Breaking Down the Jute Fibres. Jute is a very long and thick fibre when it arrives at the factory, though capable of very fine subdivision. At first, we made the mistake of trying to begin it on the carding machine, and because it did not take kindly to the operation it was sent down among the rough cordage and paper-making materials. However, jute was not to be dismissed in that way, and it was brought back among the higher fibres by the discovery, or application, of a very simple device. By the application of oil, the roughness was got rid of, and by breaking, the hardness and thickness of the fibre was reduced.

Batching. We expect jute to have been cleaned by our fellow-subjects in India, and the first thing we do is to open out the bales and lay out the fibres in stricks. This done, we lay it out for oiling. A mixture of oil and water should first be made up. Several recipes for the mixture are given; but the best, in our opinion, is the following: ⅜ gallon whale oil, ⅜ gallon seal oil, ¼ gallon mineral oil, 5 to 7 gallons of water; heat to 90°, spray the oil over each layer, and form a stack, then leave to itself for a period.

Hand batching, though not wholly discarded, as outsiders are led to suppose, has been largely supplanted by a method which combines both batching and softening.

Softening. The softening process is similar to that called *breaking* by flax-spinners. But the softening machines, especially those of old date, are tremendous structures, beside which all other breakers are mere trifles. Four tiers of ten rollers each, working one above the other, were those old machines. Modern softeners [**54**], however, are smaller structures, though very long. The smallest has 13 pairs, and the longest 18 pairs, of fluted rollers. Some rollers are fluted horizontally, but others have the deep corrugations made in a spiral form. Note the gearing of the rollers. It is peculiar. Instead of being driven direct, the rollers have their sockets set so as to derive a rippling or reciprocating action. As the stricks are fed in, they are carried between roller after roller, and thus wrought upon by the reciprocating rollers, gently and firmly softened down. When machine oiling is combined with softening, a spraying machine, containing oil and water, is set on the machine, and, by the action of the rollers, is wrought into the fibres.

Like flax and hemp, jute is assorted, weighed, and then sent forward to the carders.

RAMIE

Preparing Ramie. Before we can hope for cheap and effective methods of preparing ramie, the cultivation of the plant must be established on a proper basis. The fibres imported from the native growers of India are needlessly difficult to deal with; those from China are better, but not as well prepared as we would like. Stripped from the stems, the bark and inner fibre, glued together by the dried gum, are shipped hither to be spun. The bark is worse than useless; having been allowed to harden, the gum is difficult to dissolve, though easily soluble when fresh. It is to be hoped that, in the near future, the elaborate processes now necessary for the preparation of the fibre will be found unnecessary.

Degumming. For the dirty strips of Indian ramie the treatment is long and somewhat intricate, involving rather the trained observation of the chemist than the practical skill of the spinner or mechanic. The process is a bleaching, cleansing, and degumming operation, involving no fewer than eight baths, as well as much water. The following are the stages of the process: 1, steep in strong soda lye; 2, lay in a bath of hydrochloric acid (this is a ferment, and the retting action must be carefully watched); 3, repeat number 1; 4, put into a bath of permanganate of potash; 5, wash out the last with hyposulphite of soda mixed with hydrochloric acid, to assist in the solution of remaining vegetable gum; 6, bath of hyposulphite of soda alone; 7, rinse in a weak solution of hydrochloric acid; 8, steep in soapy water, wash thoroughly, then dry. Forbidding as it seems, when one takes into account the powerful nature of the acids, the process is not at all difficult, and the results are very fine.

The Chinese, who make the fibre themselves into cloth, send out ramie in a clean and partially degummed condition. Our treatment is therefore much shortened. The usual process is as follows: 1, boil 7 hours in a solution of soda lye, then wash; 2, steep 10 hours in chloride of lime solution; 3, ret in a solution of sulphuric acid and vitriol; 4, wash clean. This produces a fine white filasse. By comparing the two preparatory processes, it will be perceived what an enormous difference even a partial degumming of the green fibre makes.

Oiling. After passing through acids so strong, the fibre is harsh and dry. Any of the methods of applying oils to textile fibres may be adopted, but it must be thorough and yet free from clogginess. A very good mixture for oiling is made as follows: to 15 gallons of water add 200 grammes glycerine, 200 grammes Castile soap, 100 grammes white wax, 50 grammes tallow; the water should be at boiling point.

Filling. When ramie has taken its place as a great branch of the textile industry special machinery will be devised to deal with it. At present it can be very well treated by the same machines as those employed on silk waste.

Taken from the oiling batches, the fibre is fed on to the feed lattice of the filling engine, and is carried up to the spiky rollers, which drag and tease out the threads. Beyond the topmost roller runs the huge filling drum, with serried spikes at intervals of 3 in. protruding. The slender points of the long row of spikes catch into the last roller and pull away the threads; the next row comes round, and, while helping the first, also takes a share of its own. Thus the great drum becomes clothed with threads of fibre. When full, the cutter comes and cuts the threads at the root of each row of spikes, forming even layers of fibres 3 in. or 4 in. long, according to the width of space between the spikes.

Dressing. From the face of the drum the layers of ramie are gathered, and clamped in the wooden holders of the dressing machine. The endless band, with its combs, comes round and hackles at the ramie threads held in the clamps, or books, in the bed of the machine, dragging away the short and combing out the long. When one end is finished, the other is turned to the combs. The combings are run through again, just as in the case of silk, sometimes four draughts being taken. The short fibres remaining are often mixed with cotton; at any rate they can be spun in the very same fashion as cotton. The combed fibres are now ready to be carded into a sliver.

Continued

Continued from page 1261

STRENGTH OF IRON & STEEL

Strength in Tension, Compression, Shear, Torsion, &c. Test Pieces. Machines used for Testing. Allowable Working Stresses

By Professor HENRY ADAMS

Wrought Iron. Wrought iron is not homogeneous; from its mode of manufacture it consists of layers of iron interspersed with slag or scale, in such a way as to resemble somewhat a bundle of fibres, and it is, therefore, commonly described as fibrous. It is seldom tested otherwise than for tension or torsion.

Tensile Strength. For tension the sample piece is usually prepared as **78**, when from a plate, bar, tee, angle, channel, or other shaped section. The narrow part is made accurately parallel and the transverse sectional area carefully measured. Two dots are made with a centre punch as shown, exactly 8 in. apart, to allow of the extension under stress being recorded. Other distances, as 6¼ in. (100 sixteenths of an inch), or 10 in., are sometimes used, both to facilitate decimal measurement; but 8 in. may be looked upon as the standard. The wide part at each end is gripped between the scored faces of a vice attached to the testing machine. The elongation with any given intensity of stress (pounds or tons per square inch), or at final rupture, is recorded, and also the contraction at point of fracture. When the stress is applied, the lengthening is partly due to actual stretch increasing the inter-molecular spaces and partly to the flowing of material from the neighbourhood of the place where fracture occurs. The elongation and contraction are greatest with Yorkshire iron, which is uniformly soft, and less with iron of poorer quality, especially where any portion of the fracture shows visible crystals.

Toughness. *Toughness*, or ability to withstand sudden blows, is made up of direct resistance and elongation under stress, and may be measured by their product, or, in other words, by the units of work done in producing fracture. Test specimens from rods, shafts and axles are often prepared in the lathe, as **79**, and care has always to be taken that the change from the minimum section to the size requisite for holding in the clips is made very gradually. In one case that came under the notice of the writer, the pieces were prepared as **80**, and all failed at the point marked × owing to the abrupt change of diameter, although the sectional area here was four times as great as that of the central portion. Rivet iron is often tested in the original bar without preparation, being merely clamped between curved jaws at each end.

In consequence of the mode of manufacture there is a noticeable difference between the tensile strength with the grain and across the grain, the difference being about 10 per cent. In the former case the fibres have to be broken across and in the latter case they are only separated. Although the iron may be of the same general quality the tensile strength will vary, according to whether the sample piece is from a solid bar, a shaped section, or a plate, and in the latter case whether tested with or across the grain, as just stated. The result of 587 experiments by David Kirkaldy & Son gave the following figures.

Number of Experiments.	Breaking Weight per Square Inch of Original Area.		
	Highest.	Lowest.	Mean.
	Tons.	Tons.	Tons.
188 rolled bars	30·7	19·9	25·7
72 angles and straps ..	28·5	16·9	24·4
167 plates, lengthwise ..	27·9	16·7	22·6
160 plates, crosswise ..	27·1	14·5	20·6

Wrought iron is sometimes classified for test as in the following table, which shows very clearly the difference in the quality.

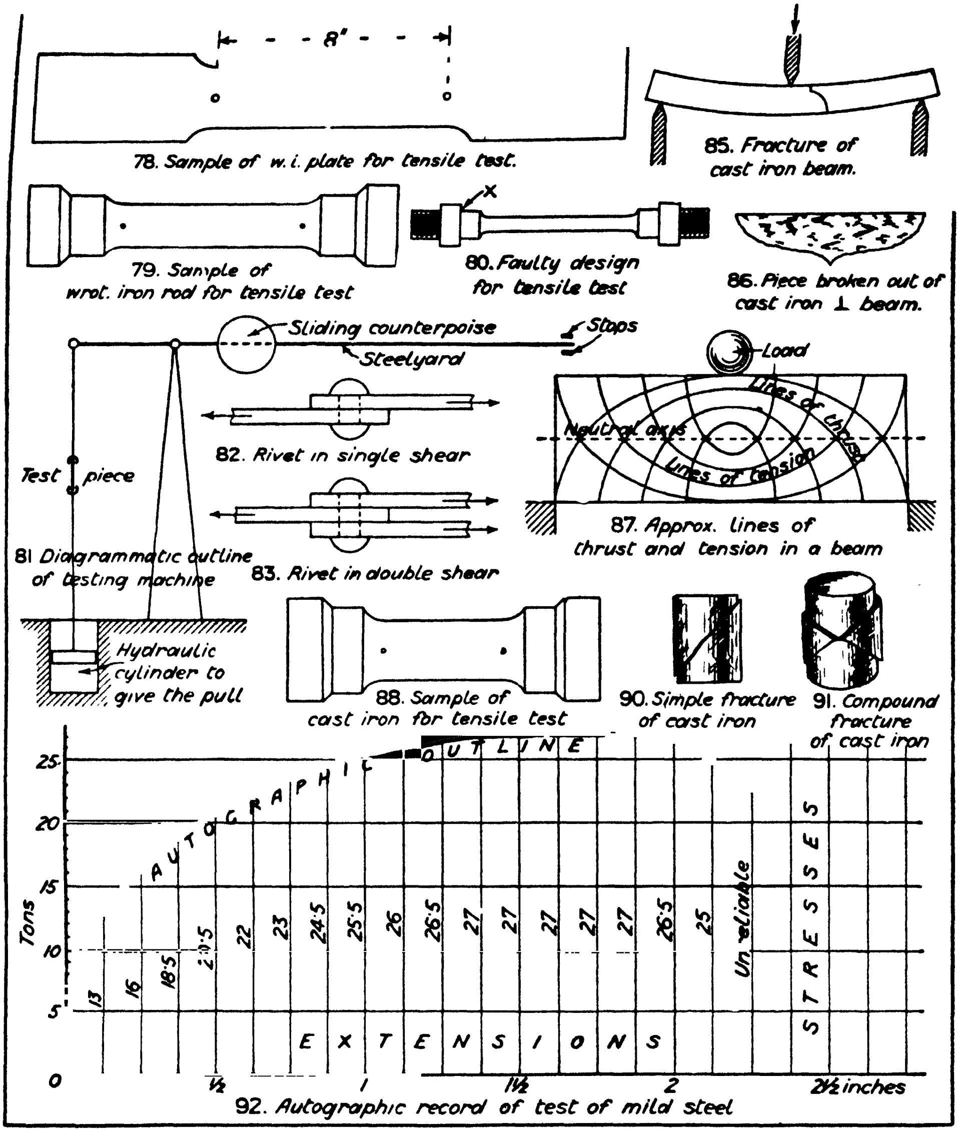
COMPARATIVE STRENGTH OF WROUGHT IRON

Quality.	Ultimate Tensile Strength in Tons per Sq. In.		Elongation per cent. in length of 8 in.	
	With Grain.	Across Grain.	With Grain.	Across Grain.
Best Yorkshire iron ..	24	22	12	7½
B.B. Staffordshire iron	22	19	9	5
B. Staffordshire iron ..	20	18	6	2½

The Admiralty give a somewhat similar classification in their specifications, as shown in the following table.

ADMIRALTY SPECIFICATIONS

—	Tensile Stress. Tons per Sq. In.	Elongation Per Cent. in 8 in.
B.B, or First Class Iron—		
Rivet and bolt iron, and bars, square, round, or flat ..	24	15
Angle, tee, channel, and flats of 12 in. width and under	22	10
Plates, lengthways	22	8
„ crossways	18	3
B., or Second Class Iron—		
Bars, square, round or flat ..	22	10
Angle, tee, channel, and flats of 12 in. width and under	21	8
Plates, lengthways	20	7
„ crossways	17	2½


8′
78. Sample of w. i. plate for tensile test.
85. Fracture of cast iron beam.
79. Sample of wrot. iron rod for tensile test
X
80. Faulty design for tensile test
86. Piece broken out of cast iron ⊥ beam.
Sliding counterpoise
Steelyard
Stops
Load
Lines of thrust
Neutral axis
Lines of tension
82. Rivet in single shear
Test piece
83. Rivet in double shear
87. Approx. lines of thrust and tension in a beam
81 Diagrammatic outline of testing machine
Hydraulic cylinder to give the pull
88. Sample of cast iron for tensile test
90. Simple fracture of cast iron
91. Compound fracture of cast iron
AUTOGRAPHIC OUTLINE
Tons
0
5
10
15
20
25
13
16
18
18·5
20·5
22
23
24·5
25·5
26
26·5
27
27
27
27
27
26·5
25
Unreliable
EXTENSIONS
STRESSES
½
1
1½
2
2½ inches
92. Autographic record of test of mild steel

DIAGRAMS ILLUSTRATING THE TESTING OF IRON AND STEEL

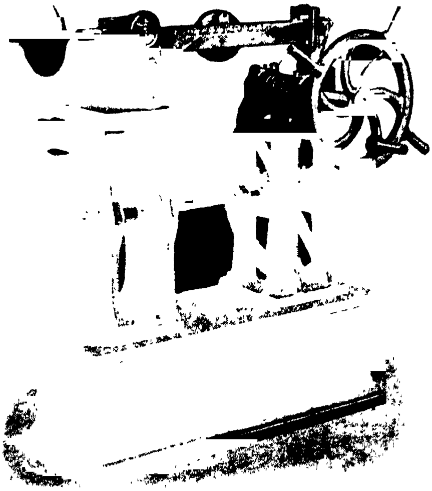
Testing Machines. A simple testing machine is shown in diagrammatic form in **81**. The water pressure being admitted above the piston puts a certain tension upon the test piece which is balanced by the counterpoise being made to slide upon the steelyard until its point is central between the stops, then more water is admitted to the cylinder to increase the load, and the counterpoise shifted further along. These operations may go on simultaneously until fracture occurs, when the position of the counterpoise on the graduated steelyard shows the stress upon the specimen. The power of the machine may be from 5 to 300 tons, but the larger machines have more complication, being fitted for all kinds of tests, and generally with automatic recorders.

Compressive Strength. Under compressive stress wrought iron bulges when in short pieces, and bends when longer, and under transverse stress, unless in a very short length or of hard and crystalline structure, a solid bar bends so much that no very exact measure of strength is obtainable, but a flanged section may be tested to destruction by a transverse stress. This will be dealt with under the head of STABILITY OF STRUCTURES. The compressive strength of wrought iron may be taken approximately at 80 per cent. of the tensile strength, but the working allowance will always depend upon the length of the piece.

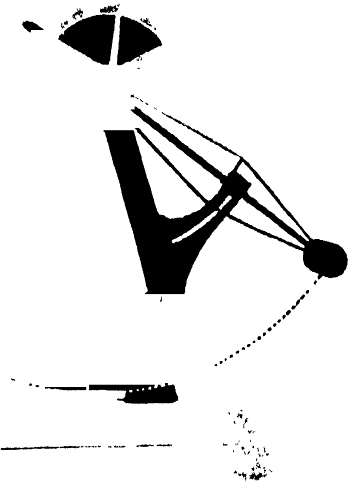
Shearing Strength. The shearing strength of wrought iron averages 85 per cent. of the tensile strength, or roughly, four-fifths. When bars are riveted, as in **82**, the rivet is in single shear, and when joined, as in **83**, the rivet is in double shear ; in the former case the joint may fail by shearing through the rivet between the plates, and the full shearing strength due to the sectional area of the rivet is allowed ; in the latter case, the joint cannot fail without shearing the rivet in two places, but the holes may not be quite perpendicular to the plane of the bars, and where several rivets go through the pieces some of the holes may not be quite opposite each other, so that the rivets do not all come into action at the same instant. Owing to the possibility of the progressive failure it is customary to allow only one and a half times the strength for double shear over that of single shear.

Torsional Strength. The average torsional strength of wrought iron is such that a round bar 1 in. diameter will be broken with a load of 750 to 800 lb. acting at a radius of 1 ft.

The machine for testing the torsional strength of metals, illustrated below in **84**, was specially designed for the Birmingham University, but is now made for general use. It is constructed on an improved principle, whereby its power can be increased for testing large specimens. By this means more accurate readings are attainable for smaller specimens. The torsion is effected by hand through "worm and wheel" gear, the test being easily accomplished by one operator. The steelyard poise is worked by a screw arrangement, thus enabling the steelyard to be kept in exact equilibrium during the testing of specimens. The strain is recorded in single pounds by means of a vernier upon the sliding poise and a finely graduated scale attached to the end of the steelyard, the fine graduations being read by means of a microscope. The machine is capable of testing specimens up to 1 in. in diameter and 12 in. in length.



84. TORSIONAL TESTING MACHINE



89. IMPACT TESTING MACHINE

Transverse Strength. Wrought iron is not often tested for transverse strength, as, unless the piece be very short or the iron crystalline, it yields so much by bending that no definite result can be obtained. It is, however, sometimes necessary to ascertain the resistance to transverse stress in order to calculate the strength of shafting, handrails, gudgeon pins, etc. But it is usually assumed that the modulus of transverse rupture and the extreme fibre stress are identical and equal to the ultimate tensile stress. The following table, however, shows that there is no direct relationship between these elements.

Material.	Ultimate Tensile Strength. Lbs. per sq. in.	Modulus of Transverse Rupture.
Spruce fir ..	2,900 to 12,000	9,000 to 12,300
Pitch pine ..	4,700 to 12,000	8,910 to 14,000
English oak ..	6,000 to 19,000	9,600 to 13,600
Teak	3,300 to 15,000	12,000 to 19,000
Kauri or Cowrie	9,600 to 10,900	9,600 to 11,000
Cast iron ..	11,200 to 29,120	30,240 to 45,700
Wrought iron ..	35,840 to 64,960	41,200 to 51,520
Mild steel.. ..	62,720 to 71,680	53,760 to 114,240

Bending Tests. The toughness of wrought iron and its freedom from lamination are also tested by cold bending in a vice ; ½ in. plate should bend 35 deg., ⅜ in. plate 55 deg., $\frac{5}{16}$ in. plate 63 deg., ¼ in. plate 70 deg., while rivet iron, which needs to be very soft and pure, should bend double without cracking.

Cast Iron. Cast iron is generally tested for transverse strength only. At one time, small test bars were cast as projections from an important casting and broken off for testing, but this method was found to give results 10 to 20 per cent. lower than when bars of the same size were cast separately from the same metal.

Transverse Tests. The best practice is now to cast three bars, each 3 ft. 6 in. long, and 2 in. deep and 1 in. wide, cast on edge in a dry mould, from each melting at which any of the specified work is cast. These bars are tested separately, as follows. The lower side, or thin edge, of the casting is placed downwards upon rigid bearings, with 3 ft. clear span; if placed the other way up, a reduction in the apparent strength of 15 to 20 per cent. may occur. A load of 25 cwt. being placed in the centre of the bar, with a bearing not more than 1 in. wide, the deflection should not be less than $\frac{3}{10}$ in., and the bar should break with a minimum load of 28 cwt., or an average upon the three bars of not less than 30 cwt.

A curious fact that throws light upon the nature of the strains set up in the bar is that the *course of the fracture* varies according to its *position in the bar. When the fracture occurs* within an inch of the centre of the span, it takes an approximately straight line at right angles to the length of the bar, but about 25 per cent. of the fractures take place further away, on one side or the other of the centre, and they are then always curved away from the centre, as in **85**. *A short straight part often occurs at the top, and this is apparently the part under direct* compression. *Hodgkinson found in testing cast-iron* ⊥ beams that with the rib in compression a piece was invariably broken out from the centre, as **86**. These facts appear to show lines of thrust and tension, roughly illustrated in **87**.

Lathe Tests. Samples prepared in the lathe, as **88**, should bear a tensile stress of 2½ tons per square inch before appreciable loss of elasticity, but the actual limit of elasticity of cast iron is somewhat indefinite, as even the smallest loads produce some permanent set. The sample should break with not less than 7 tons per square inch, or an average of 7½ tons per square inch on three samples.

Pipe-iron Tests. The following is a specification test of cast iron for pipe-making where tensile strength and soundness are of importance. "A bar 40 in. long, 2 in. deep and 1 in. wide, the weight of which must not exceed 21 lb., shall, when supported on edge at points 36 in. apart, deflect $\frac{1}{10}$ in. with a load of 10 cwt. in the centre, and recover its position when the load is removed, and shall sustain a load of 3,000 lb. supported at the middle of its span for one hour, and shall, under this load, deflect at least $\frac{3}{8}$ in.; and a bar 8 in. long and 1 in. square in section, shall sustain a load of 8 tons per square inch for one hour." The latter is, of course, a tensile test.

Practical Tests. Tredgold gave a very practical account of the essential points to be observed in testing cast iron by simple inspection. He said: "The best and most certain test of the quality of a piece of cast iron is to try any of its edges with a hammer; if the blow of the hammer makes a slight impression, denoting some degree of malleability, the iron is of good quality, provided it be uniform; if fragments fly off and no sensible indentation be made, the iron will be hard and brittle. The utmost care should be employed to render the iron in each casting of uniform quality, because in iron of different qualities the shrinking is different, which causes an unequal tension among the parts of the metal, impairs its strength, and renders it liable to sudden and unexpected failures. When the texture is not uniform, the surface of the casting is usually uneven where it ought to be even. This unevenness, or the irregular swells and hollows on the surface of a casting, is caused by the unequal shrinkage of the iron of different qualities."

Testing Machines. The machine illustrated on page 1250 is very suitable for testing cast iron, both transversely and in tension. The samples prepared in the lathe have the outer skin turned off, and the apparent strength is reduced, but the result is, perhaps, a closer *approximation to the real strength than when a square bar is tested with the skin left on.*

Impact Tests. Castings are frequently tested for motor work by means of impact, as they have to stand sudden shocks and require to be very tough. A suitable machine is shown in **89** [page 1393]. A pendulum weight is raised to a height and allowed to swing and strike the test-piece, fracturing it at one blow, and the number of foot-pounds of energy which the test-piece has absorbed is automatically registered on the indicating quadrant.

Compression Tests. Cast iron is seldom tested for compression in practical work; it has, however, frequently been tested thus experimentally, with very interesting results. Being a crystalline substance, it breaks with a line of fracture at a mean angle of 55 deg. with the horizontal, whether the fracture be simple, as **90**, or compound, as **91**, and sometimes the exterior breaks away, leaving two inverted cones, which crush into each other if the pressure be continued too far. The failure appears to be a result of shearing through the line of least resistance, and not direct crushing.

Malleable Cast Iron. Malleable cast iron, consisting of ordinary cast iron from which some of the carbon has been abstracted to toughen it, has an ultimate tensile strength of about 14 tons per square inch, an elastic limit of about 7 tons, and an elongation of 1½ per cent. on a length of 4 in.

Cast Steel. Cast steel is very similar to cast iron in its properties, but very much stronger. The chief difficulty with the material is the frequency of honeycombing, or a series of holes, caused by bubbles of gas being shut in. Cast steel is seldom subjected to mechanical tests except for special purposes. Where a large number of similar castings are required, a certain percentage of them are sometimes tested by the impact of a falling weight.

Mild Steel. The extended use of mild steel, and the difficulties which surrounded its early production and use, have caused a very large amount of thought and money to be expended upon producing the most complete and perfect system of testing which could be devised.

The mechanical testing has been accompanied by chemical tests of the same material, so that the effect of each constituent and impurity, according to its amount, is now so well known that steel can be made to comply with almost any specification, according to the purpose for which the material is required.

Corresponding physical and chemical tests are given in the following tables.

PHYSICAL TESTS.

Brand.	Point of Permanent Set in Tons per Square Inch.	Tension in Tons per Square Inch.	Elongation. Per Cent.
Mild steel	17·92	28·86	45·00
Medium steel ..	20·87	33·25	35·92
Hard steel	25·60	39·84	30·50
Tool steel	..	57·68	14·40
Very hard steel ..	..	68·67	7·00

CHEMICAL TESTS.

Brand.	Carbon.	Manganese.	Silicon.	Phosphorus.	Sulphur.
	%	%	%	%	%
Landore mild steel	·18	·64	·013	·077	·074
Mild steel ..	·22	·399	·062	·043	·042
Medium steel	·34	·536	·024	·052	·019
Tool steel ..	·97	·148	·074	·034	·059

Tensile Tests. The tensile tests are the most important in connection with mild steel. The material is homogeneous, showing no grain in either direction. It is highly ductile and draws out with a silky fracture, very commonly in the shape of a short cone on one piece and a corresponding hollow on the other piece. There is sometimes an autographic recording apparatus attached to the testing machine, which gives a graphic representation of the phenomena of the tests; such a record is shown in 92. It will be seen that for a certain distance the elongation is slight and regularly proportionate to the stress, and that when the stress reaches 12 tons per square inch, which is the *elastic limit*, a sudden slip occurs, called the *yield point*, and that after that the elongation is much more pronounced. Another remarkable feature occurs towards the end of the test, where the backward curving of the line shows a falling off in the stress, due to the rapid drawing out of the specimen and simultaneous contraction of transverse area at the ultimate point of fracture. After the yield point is passed, time is an important element in the test—the quicker the test the greater the stress that can be applied before failure occurs, showing that the cohesion of the material is so far destroyed that ultimate failure with a much lower stress is only a question of time, and hence the danger of allowing any working stresses to exceed the elastic limit by however small an amount. No one intentionally permits this to happen, but contingencies sometimes arise that are not provided for by the ordinary factor of safety.

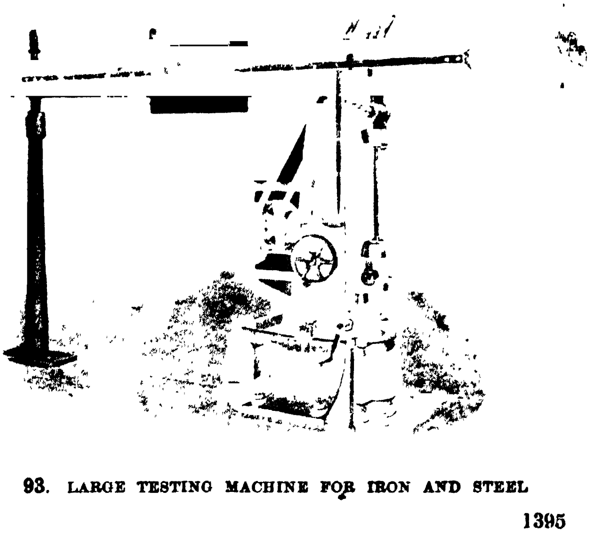
Factor of Safety. The factor of safety is an amount fixed by practical experience, varying with the material used and the manner of using. It is the ratio of the greatest safe stress to the ultimate resistance of the material—such as $\frac{1}{4}$, $\frac{1}{10}$, etc.; and the calculated resistance of any section, multiplied by the factor of safety suitable to the circumstances, will give the safe working load.

If structures never deteriorated they might be loaded to one-third of their breaking weight with perfect safety, but to guard against ordinary contingencies one-fourth of the breaking weight is the maximum permanent load allowable under any circumstances.

The factor of safety is usually given in the reciprocal form, as 4 or 4 to 1, etc., meaning that the ultimate calculated resistance is four times the working load, thus:

$$\text{Factor of safety} = \frac{\text{Breaking load}}{\text{Working load}}.$$

Allowance for Dead Load. It is convenient to sum up the usual allowance for working stresses in tons per square inch under dead load upon iron and steel in structural work; the figures for compression and shearing assume that the parts are unable to bend.



93. LARGE TESTING MACHINE FOR IRON AND STEEL

STRENGTH OF METALS AND ALLOYS

Material.	Ultimate Strength. Tons per Sq. In. Tension.	Compression.	Shearing.	Modulus of Rupture in Tons.	Specific Gravity.	Weight in lbs. per Cub. Ft.	Weight in lbs. per Cub. In.	Modulus of Elasticity in lbs.
Aluminium-bronze ..	25 to 40	58	—	—	7·68	478	·276	14,000,000
Aluminium, cast ..	4 to 6	5	—	—	2·59	161·25	·0936	11,000,000
„ sheet ..	6 to 10	—	5 to 6	—	2·74	170·6	·0986	—
Antimony, cast.. ..	½	—	—	—	6·72	419	·242	—
Bellmetal	1·4	—	—	—	8·05	502	·29	—
Bismuth, cast	1½	—	—	—	9·84	614	·353	—
Brass, cast	8 to 12	5 to 25	—	7·2	7·8 to 8·4	487 to 524	·28 to ·303	9,000,000
„ sheet	14	—	—	—	8·44	527	·304	—
„ wire	20 to 22	—	—	—	8·54	534	·307	14,000,000
Bull's metal, cast ..	14 to 21	60 to 78	—	—	8·28	517·5	·30	—
Copper, bolts	15 to 17	40	14	—	8·8	550	·32	16,000,000
„ cast	8 to 10	20 to 25	—	—	8·6	537	·31	11,000,000 to 13,000,000
„ sheet	13 to 15	40	—	—	8·78	548	·316	12,800,000 to 16,800,000
„ wire	25 to 27	—	—	—	8·9	555	·32	17,000,000
Delta metal, cast ..	20 to 40	60 to 70	—	—	—	—	—	—
„ „ wire ..	62·5	—	—	—	—	—	—	—
Gold	9	—	—	—	19·28	1,203	·70	12,000,000
„ standard ..	—	—	—	—	17·72	1,106	·638	—
Gunmetal	12 to 16	15 to 50	8 to 12	—	8·54	534	·307	10,000,000
Iron, cast	5 to 13	36 to 64	8 to 14	13·5 to 20·4	7·2	450	·26	18,000,000
„ wrought	16 to 29	16 to 18	17 to 20	18·4 to 23	7·7	480	·28	25,000,000
„ „ rivets ..	22 to 26	—	22	—	—	—	—	26,000,000
„ „ wire ..	25 to 40	—	—	—	—	—	—	15,000,000
Lead, cast	¾ to 1¼	3·1	—	1·5	11·36	710	·408	720,000
„ milled	1¼ to 1½	—	—	—	11·4	712	·41	—
Mercury..	—	—	—	—	13·596	848·75	·48945	—
Muntz metal	20 to 30	—	—	—	—	—	—	—
Nickel, forged	—	—	—	—	8·66	540	·31	—
„ ingot	—	—	—	—	8·28	517	·30	—
Pewter	—	—	—	—	7·26	453	·26	—
Phosphor bronze ..	15 to 26	50	—	—	8·6	537	·31	14,000,000
Platinum	—	—	—	—	21·53	1,344	·775	23,500,000
Silver	18	—	—	—	10·5	654	·377	10,700,000
„ standard.. ..	—	—	—	—	10·4	650	·376	—
Speculum metal ..	3·1	—	—	—	7·45	465	·264	—
Steel, cast	35 to 52	150	—	—	8	499	·288	42,000,000
„ mild	28 to 32	26	24	24 to 51	7·85	490	·28	29,000,000
Tin	2	6·7	—	—	7·291	455	·262	5,000,000
White metal (Babbitt)..	—	—	—	—	7·3	456	·263	—
Zinc, cast	3	15	—	6	6·97	435	·25	13,000,000
„ sheet	—	—	—	--	7·19	448	·259	—

PHYSICAL DATA FOR METALS AND ALLOYS

Material.	Specific Heat.	Melting Point. Deg. Fahr.	Coefficient of Expansion by Heat.	Latent Heat of Fusion.
Aluminium	·2185 to ·234	1,200 to 1,300	·00001235	51·4
Aluminium-bronze	—	1,910	—	—
Antimony	·0507	800 to 810	·000006	—
Bellmetal	—	507	—	—
Bismuth	·0308	480 to 507	·0000078	22·8
Brass	·0939	1,800 to 1,850	·00001894	—
Copper	·095	1,950 to 2,050	·000009	—
Gold	·0298	2,100 to 2,280	·000009	—
Gunmetal	—	1,900	—	—
Iron, cast	·1268	2,000 to 2,750	·000006	—
„ wrought	·1138	3,250 to 4,300	·0000066	—
Lead	·0293 to ·0314	612 to 620	·0000155	9·7
Mercury	·032	−38·8	·000099	5·1
Nickel	·1086	2,810 to 2,912	·00000695	—
Platinum	·033 to ·038	3,080 to 3,500	·000005	—
Silver	·0557	1,830 to 1,873	·00001055	38·0
Steel, cast	—	2,850 to 3,300	·00000695	—
„ mild	·1175	2,550	·00000672	—
Tin	·0562	435 to 450	·0000121	25·7
Zinc	·094	750 to 800	·0000161	50·7

MAXIMUM WORKING STRESSES IN TONS PER SQUARE INCH

Material.	Constant Load.	Variable Loads.	
Wrought iron for machinery	Tension only, 5 Compression only, 4	Tension only, 3 Compression only, 2½	Alternate tension and compression, 1¼
Mild steel for machinery ..	Tension only, 7½ Compression only, 6	Tension only, 4½ Compression only, 3¾	Alternate tension and compression, 2¼
Cast iron for machinery ..	Tension only, 1½ Compression only, 6	Tension only, ¾ Compression only, 4½	Alternate tension and compression, ¾

USUAL ALLOWANCE FOR DEAD LOAD

Material.	Ultimate Stress per Sq. In.	Safe Load per Sq. In.
WROUGHT IRON—	Tons.	Tons.
Tension	22	5
Compression	18	4
Shearing	20	4
Bearing	—	7½
MILD STEEL—		
Tension	30	7½
Compression	26	6
Shearing	24	5
Bearing	—	10
CAST STEEL—		
Tension	35	8
Compression	50	12
Shearing	—	7½
Bearing	—	15
CAST IRON—		
Tension	7	1½
Compression	42	7½
Shearing	14	2½
Bearing	—	8

Allowance for Varying Stresses. Another useful summary may be made of the allowable working stresses under constant and varying loads, such as may constantly be found in machinery.

TORSIONAL STRENGTH OF VARIOUS METALS

Round bars 1 in. diameter, load applied at 1 ft. radius.

Cast steel	1,250 to 1,500 lb.
Mild steel	1,000 „ 1,200 „
Wrought iron ..	750 „ 800 „
Cast iron	600 „ 700 „
Wrought copper .	350 „ 400 „

Any account of the strength of mild steel at the present day would be incomplete without mention of the specifications issued by the Engineering Standards Committee. These, so far as they are yet completed, may be obtained from Crosby Lockwood & Son at prices varying from 2s. 6d. to 10s. 6d. each.

The tables on this and on the opposite page give particulars of the strength of metals and alloys, the specific gravities, weight, modulus of elasticity, specific heat, melting temperatures, latent heat of fusion, coefficient of expansion by heat, contraction in cooling, and relative conductivity for heat and electricity.

CONTRACTION OF METALS IN COOLING

Metal.	Contraction	
	In fractions of linear dimensions.	In parts of an inch per foot of linear dimensions.
Cast Iron..	$\frac{1}{96}$	$\frac{1}{8}$
Gunmetal	$\frac{1}{72}$	$\frac{1}{6}$
Yellow brass	$\frac{1}{64}$	$\frac{3}{16}$
Copper	$\frac{1}{60}$	$\frac{1}{5}$
Zinc and tin	$\frac{1}{48}$	$\frac{1}{4}$
Lead..	$\frac{1}{30}$	$\frac{5}{16}$

RELATIVE CONDUCTIVITY OF METALS

Metal	Heat.*	Electricity.†
Silver	1,000	1,000
Copper	736	733
Gold	532	585
Brass	236	215
Tin	145	226
Iron	119	130
Steel	116	—
Lead	85	107
Platinum	84	103
Palladium	63	—
German silver	60	—
Bismuth	18	19

* Wiedemann and Franz. † Lenz.

Large Testing Machine. A modern high-class testing machine suitable for tensile, compressive, and transverse tests is shown in 93 [page 1395]. It is of single lever type, upon the same principle as 81, and is capable of working up to a maximum of 150 tons. The weigh-beam or lever is built up of strong steel plates fitted with best hardened steel knife-edges, the main and fulcrum knife-edges being 20 in. long, to comply with the Board of Trade requirements. The graduations on the lever are machine divided, and, in conjunction with a vernier, sub-divisions of $\frac{1}{100}$th of a ton are attained. The sliding weight on the lever is a standard weight; this is propelled along the beam by means of a screw worked by power, and for the fine adjustments through gearing by a hand-wheel fixed on the column. Buffer springs are provided at top and bottom of pillar standard to lessen the shock to the lever when the specimen breaks. The strain is applied by hydraulic power through a cylinder and ram, and the appliances for holding the specimens are of cast steel accurately machined to gauge. Large testing machines should always stand upon a solid foundation, and not be subject to earth tremors. The slightest communicated vibration will lower the result, on the same principle that one taps a barometer to lessen the friction of the mobile particles of metal.

Continued

INVENTIONS AND INVENTORS

Profitable and Unprofitable Inventions. Some Popular Fallacies Regarding Patents. Searching the Patent Office Records

INVENTION presents to the average man all the fascination held by any possible means *of acquiring sudden wealth. Yet, among the thousands of inventors, professional and amateur,* in this and other countries, a relatively small proportion have acquired even a livelihood from invention pure and simple. Very often the inventor is a schemer and a dreamer, void of the ability to turn his invention to profitable account. Thus, he often permits the golden fruits of his ideas to be plucked by other hands. It is difficult or impossible to teach the individual what to invent and how to invent it, but it is possible to analyse the various fields in which inventive faculties may be exercised with promise of greatest results, to point out the pitfalls which the inventor should avoid, and to show the several ways open to him of turning his invention to practical value.

Methods of Invention. Inventions are achieved in three different ways. The article or process may be the result of steady persistent work and exhaustive experiment, with the clear aim of mastering the difficulties in the path of success. Intricate mechanical inventions are always the product of such work. We may instance the typewriter and the Linotype and other type-setting machines as examples In these the inventors had a fixed, definite purpose as their goal, and all their efforts were bent to the devising of mechanical means to achieve that purpose. Of the result we all know something. The typewriter has revolutionised mercantile office practice; and of machine type-setting the SELF-EDUCATOR is an illustration. In the domain of chemical invention the manufacture of artificial indigo is a conspicuous example of success through deliberate and persistent work. In 1878, the founders of the Badische Anilin und Soda Fabrik set themselves to discover an economical method of manufacturing indigo, and spent nearly £1,000,000 in experimental work and plant, until, in 1898, they were able to market artificial indigo. They started with full confidence in the belief that what Nature can do by the agencies through which she works, man can do by synthetic chemistry. The result is that fortunes have accrued to the inventors and to many others besides, and that the ultimate issue will be the death of indigo cultivation.

The second road by which invention is reached is by inspiration. To this province belongs the invention of very simple mechanical articles of everyday utility. It was long known to chemists that a combination of certain salts burst into flame when subjected to friction, but it was an inspiration that caused a chemist and druggist of Stockton to cover the end of a slip of wood with sulphur and to tip it with sulphide of antimony and chlorate of potash, thereby producing the first lucifer match. So also inspiration brought into being the safety-pin, and a host of small articles of everyday use and utility.

Inspiration led Peter Barlow to attach a telescope to the front of a photographic camera, and the example he set has discovered for us new stars too remote for detection by the retina of the human eye.

Then we have the third method of achieving invention—accident; very often, indeed, the experimenter looks for something quite different from that which ultimately rewards him. The lithographer's stone and saccharine are conspicious examples of this class.

Inventions found by accident have sometimes been lost. Every investigator in the realm of photographic chemistry seeks a method or a medium by which he may record a scene or an object in its natural colours with no more trouble than that involved in taking an ordinary photograph. The coloured photographs sometimes put forward are merely the result of the superposition of differently coloured films, and the most that can be said for them is that they portray the colour effect fairly well. A coloured photograph was accidentally produced as long ago as 1852, and was exhibited by Joseph Sidebotham at a meeting of the Manchester Literary and Philosophical Society, in 1857. It was on glass and represented a red geranium and its green leaves. Although Sidebotham spent many years trying to repeat the photograph, neither he nor any of those who have worked in the same experimental field have succeeded.

What to Invent. No specific answer can be given to the query "What shall I invent?" The probability is that a man's invention has some connection with the field in which his work lies. It is not always so. Arkwright, who invented the spinning jenny, was a barber, and Edmund Cartwright, who was responsible for the power loom, was a clergyman. It is not impossible to indicate in what channels inventions are least likely to bring remunerative returns. Some of the fancies that result in letters patent are ludicrous in the extreme to the practical mind. For instance, a lady has taken out British patent rights for a process by which she professes to harness the power that runs to waste when an earthquake comes around. It is easy to smile at such a ludicrous exhibition of misapplied ingenuity. Having had our smile, we may point the moral.

The would-be inventor without a distinctly mechanical bent of mind should avoid mechanical inventions, except those of the very simplest types. How many men have spent years in trying to solve the problem of perpetual motion when a knowledge of the elements of dynamics would have taught them that the search was vain ?

An invention may be valuable in itself, but have small chance of bringing money to its creator. It may be wanted by only very few people. For instance, an instrument for ascertaining with accuracy and rapidity the distance between the various stars, or a submarine boat which would, for obvious reasons, be purchased only by a government.

The ordinary man without special technical training in any particular branch of science or productive industry—and it is chiefly for such that we write—may note that the greatest chance of financial success is possessed by an invention having the following qualities.

1. It should be an article of personal use or consumption, and be used by the million.
2. It should wear out in a reasonable time, requiring replacement.
3. It should not be expensive to develop, as an airship or a complicated machine is, but should be marketable without much initial outlay.
4. It should be distinctive and superior to anything already offered for the same purpose, not merely filling the same want at the same price. Manufacturers and merchants do not take up a new article without good reason.

The Value of Inventions. The inventor is very often—temporarily, at least—a monomaniac on the subject of his invention, and is thoroughly convinced that there is a latent fortune in his contrivance. Assuming the article to be valueless, or practically so, the awakening to the true state of affairs is always painful and sometimes pathetic. The cold douche of practical opinion poured upon the fire of the inventor's enthusiasm often inflames that fire instead of quenching it. Yet it is the truest kindness to speak the plain truth when opinion is asked, because to prolong the delusion by words of well-meant sympathy is only to make the final revelation more painful and the dream more expensive.

Inventions Revolutionise Industries. Yet the inventor's dreams are often fulfilled, while the prognostications of his critics fail. Some inventions, for which failure is foretold, prove ultimately successful. "The fool is wiser in his own conceit than seven men that can render a reason." Success of seemingly unpromising inventions frequently means that the invention is so important than an industry may be revolutionised to permit its adoption. The "process block," as it is called—*i.e.*, the reproduction of illustrations by printing blocks made by the joint agencies of the photographic camera and the acid bath—may instance this group. Two difficulties barred the general use of such blocks—the unsuitability both of printing papers and of printing machines. Yet process illustration was so important that paper manufacturers and printing-machine makers had to remodel their practice, and to design special machinery to meet the requirements of the new method of reproducing illustrations. Thus we have the surface papers and hard-bed presses.

Immature Inventions. Inventions are often marketed before their details have been worked out to the full measure of their possible value, and, as a result, fall short of commercial success. The inventor is apt to ascribe too much importance to the main idea, and to imagine that the manner of applying it is less important. He may see the end to be attained, and have a conception of the general principles of an excellent method of reaching that end, but be unable to adopt the best and most simple means of reaching it. It is often so in mechanical inventions. This is where the inventor's engineer may come in and supplement general principles by the application of scientific mechanical practice. The adjustment of weight to duty, of part to part, the designing of details, the selection of material—all these are points in which the unguided inventor may go far astray, and, if left to himself, devise or manufacture a clumsy piece of mechanism which in expert hands would have had a far higher practical and commercial value.

Valueless Patents. The subjects of many patents registered in the British Patent Office are not worth the paper upon which they are recorded. One has only to examine the specifications in any given subject to find the same idea patented many times. The first is the only one really valid, and even it could not be sustained if it were proved that the idea had been public before the date of the application for letters patent. Yet, although such an article could not be proved valid if the point were challenged, there is often commercial value in a non-valid patent. Many manufacturers and inventors innocently believe that they hold undisputable titles to patents, when a search of the Patent Office records would show that they are mistaken. So long as a man works a patent himself and no one challenges it, it may be as profitable as if he were the first inventor. But should he try to sell the patent, or to form a company to take it over, a strict search would certainly be made and any anticipation found. Under the new Patent Act the Comptroller of Patents, when a complete patent is applied for, makes a search in the British patent files for the preceding fifty years, and if there has been anticipation of the identical or approximately similar idea the letters patent may be endorsed to that effect, giving number and date of any anticipations. Thus, the chances of a patent granted under the new Act being valueless are diminished, but all patents granted prior to fifty years before the date of application and the vast field of foreign patents are neglected in the search, so that acceptance of an application without endorsement does not even now stamp it as unassailable.

The moral of this is that the inventor who has any doubt regarding the validity of his invention should not attempt to negotiate a sale, but should either work it himself or have it worked for him on a modest royalty.

A Popular Delusion. It is a popular delusion that any patented invention may be manufactured with impunity if it be not made for sale but merely for the use of the individual. This is a misconception of the law on the subject. It has arisen from the fact that the law refuses to regard as infringement any purely experimental work, as it was not framed to curb inventive genius; but its word and spirit are specific in considering as an infringement the manufacture of any patented article, even though it be only for the personal use of the imitator.

Patent Medicines. The term "patent medicine" is apt to deceive. The so-called "patent medicine" is seldom the subject of letters patent, and "proprietary medicine" is the correct designation. The Government stamp on every package is rendered necessary by the wording on the label or on the advertised statement of claims for the preparation. Further information regarding the law on the subject, appears in the article on "Chemists and Druggists," in the course on SHOPKEEPING. But proprietary medicines are sometimes patented. This means, of course, that the full formula and the special manner of manufacture, if any, must be described, and that after the patent has expired, by non-payment of fees, or by having reached the time limit of 14 years, it is open to anyone to manufacture the nostrum. Thus, a well-known and widely-advertised pill was originally patented, and anyone is free to read the original recipe, and to make and sell the article, although this is not done, as no one who might care to do so seems to be aware of the fact just stated.

Patent Rights or Secrecy. This brings us to consider the comparative merits of taking letters patent, or of keeping secret, inventions which are not mechanical. A mechanical invention cannot be held in monopoly by secrecy, because its design and structure teach its manufacture. But the secret of manufacturing something produced by a chemical process may well be guarded, and it is often wise to seek to preserve monopoly thus. A conspicuous example of this is offered by the history of the Mushet high-speed steel, the manufacture of which was a secret for quite half a century. But certain risks attend preference for secrecy instead of patent privileges. The makers of a well-known infants' and invalids' food found it so. An employé who had learned the secret of the preparation, left them, and patented the methods. The makers succeeded, by an expensive legal process, in establishing their right to use the method they had invented, but the recipe was published and free to the world sooner than it would have been had they chosen to preserve their monopoly originally by taking advantage of the privileges of the Patent Act.

Patents of Workmen. In the manufacturing industries, the latent possibilities of invention in the workman at the lathe or bench are not appreciated. The man who handles the tools, or who guides the machines, is often fertile in practical ideas that would save time and money. The wise employer encourages the development of such ideas, not to the point of permitting his men to neglect their work for any fad of a mad fancy, but to the adoption upon a profit-sharing basis of any good invention suggested by a workman. Such an idea is often not the subject proper of a patent. It may be merely a quicker, and therefore cheaper, method of handling material or of performing a manufacturing operation. Nevertheless, it is distinctly an invention, and the man responsible for it is entitled to consideration apart from the money he earns as a workman. Employers are given to consider that they are fully entitled to all the ingenuity that a workman can develop. It may be noted that some of the Government Departments set the example in this attitude, and go so far as to forbid employés to patent any article of process connected with their particular work. Possibly, the regulation is the result of abuse of privileges and facilities, but its direct effect has been only to have the inventions of these interdicted Government employés patented under other names. The manufacturer with a true eye for productive economy does not follow this course of action. He has sufficient oversight of his business to be able to accept only such ideas as he finds of money-saving value, and he willingly pays the men whose everyday tasks lead him to evolve those ideas.

The Danger of Anticipation. Having fixed his invention, either by manufacturing a model, by merely making drawings, or even by having only framed a mental conception of it, the inventor naturally wishes to secure monopolistic rights. He may do this at once by applying for provisional protection; but he will be wise to ascertain first whether or not the idea has already been patented. It is not remarkable that the same occasion should inspire different individuals with similar ideas, and probably more than half of the inventions of which inventors at first believe themselves to be the originators have been anticipated.

The inventor may, if he live in London, or visit that city, search the files of the Patent Office, in Southampton Buildings, Chancery Lane, London. If it be impossible that he should make this search himself, any patent agent will do it for him, charging in accordance with the time occupied in the search. A search is usually, however, a costly business if made by an agent. There is now less occasion than formerly to have a patent agent-made search for anticipations of an invention. Under the new British Patent Act, the officials of the Department make a search in the case of every complete specification tendered for registration. But we must assume that our inventor is not prepared to squander money on complete letters patent before the probationary or provisional stage has been passed. The precise distinction between the two will be explained later.

Provincial and Colonial Searching. Facilities for consulting the patent records are not confined to the residents and visitors to London. There are many places in Great

Britain, and out of it, where the complete sets of abridgments and specifications are kept for reference. We give a list of the provincial and colonial libraries and museums where the files may be consulted

UNITED KINGDOM

Belfast—Free Public Library.
Birmingham—Reference Library, Patent Department, Eden Place.
Bolton—Little Bolton Library.
Bradford, Yorkshire—Free Library, Darley Street.
Bristol—Public Libraries, Hotwells Branch Library.
Cardiff—Central Free Library, Reference Department.
Carlisle—Public Library, Tullie House.
Derby—Public Library and Museum.
Dublin—National Library of Ireland, Kildare Street.
,, —Public Record Office.
Dundee—Public Library, Albert Institute.
Edinburgh—Royal Scottish Museum.
Glasgow—Stirling's and Glasgow Public Library, Miller Street.
Halifax—Public Library, Akroyd Park.
Horwich—Mechanics' Institute Library.
Huddersfield—Public Library and Art Gallery.
Hull—Public Libraries.
Ipswich—Free Library, High Street.
Isle of Man—Douglas—Rolls Office.
Keighley—Mechanics' Institute, North Street.
Leeds—Free Public Library.
Leicester—Free Public Library, Wellington Street.
Liverpool—Free Library, William Brown Street.
London—Free Library, London Street, Bethnal Green (from 1888).
,, —British Museum.
,, —Science Library, South Kensington Museum.
Manchester—Free Library, Deansgate.
Newcastle-on-Tyne—Public Library, New Bridge Street.
Newport, Monmouth—Free Library.
Nottingham—Central Free Public Library.
Oldham—Free Library, Union Street.
Preston—Harris Free Public Library and Museum.
Rochdale—Free Public Library, Esplanade.
Salford—Free Library, Peel Park.
Sheffield—Free Public Library, Surrey Street.
Swansea—Public Library.
Wolverhampton—Free Library.

BRITISH COLONIES, ETC.

Canada—Quebec—Montreal—Council of Arts and Manufactures of Quebec.
,, —Ontario—Ottawa—Patent Office.
,, —Toronto—Public Library.
India—Bombay—Patent Office, Secretariat.
,, —Calcutta—Patent Office, Imperial Secretariat.
,, —Madras—Patent Office, Secretariat.
New South Wales—Sydney—Public Library.
New Zealand—Wellington—Patent Office.
Queensland—Brisbane—Public Library.
South Australia—Adelaide—Colonial Institute.
,, ,, —School of Mines and Industries
Tasmania—Hobart—Public Library.
Victoria—Melbourne—Commonwealth Patent Office.
,, ,, —Public Library.
Western Australia—Perth—Public Library.

There are many other places where the abridgment volumes, but not the complete specifications, are kept for reference. The list is too lengthy to give in detail, but it may be obtained on application to the Patent Office, at 25, Southampton Buildings, Chancery Lane, London, W.C. It is worthy of note that no South African town appears among the places where complete specifications may be examined, for which reason it may serve a purpose if we place on record that the volumes of abridgments may be consulted in the Colonial Secretary's Office in Cape Town, and in the Seymour Technical Library, Johannesburg.

The Search. We shall take for granted that our inventor makes his own search. He enters the Patent Office Library, which is open from 10 a.m. to 10 p.m. every week-day, and after having signed his name in the book at the portals, all the records are ready for his inspection, without charge whatsoever. He will find on the public tables nearest to the door full sets of name and subject indexes, one volume of each for each year. If he knows the ropes, he will pass these and select the volumes of "abridgments."

In the British Patent Office patents are divided into 146 classes. The searcher must find into which of these classes his invention falls. Let us assume that he has invented a safety razor. He will find that group 30 is that for "cutlery." One abridgment volume of class 30 shows, in condensed form, all the patents in the cutlery group for the four-year period ending 1900, and every quadrennial period is the subject of another volume. Every volume is indexed. The inventor turns to "razors," and consults the specification numbers following it. He may go through all the volumes, and may consult every specification of every razor patented in Great Britain since the year 1617. Should the abridged description in the volume not convey to him sufficient details, he may examine the complete specification, which he will find upon the shelf under its year and number.

A Void Patent. A patent that has become void has, of course, ceased to be a patent, and everyone is free to make the article. It may be that our protégé with the razor invention finds that he has been anticipated. This means that he cannot secure the privileges of monopoly for the article. But he may wish to know if he is at liberty to manufacture it. Should he find that it was patented more than 14 years ago, he may be quite sure that the patent is void. Should the same article have been patented several times, and the first patent have become void, no one possesses any proprietary rights in the invention, no matter what payments may have been made by any subsequent inventor or patentee. If the payments upon the original patent have been maintained, the patent is valid, although a subsequent patentee may have ceased paying the requisite fees. A book in the Patent Office Library contains a record of payments upon every British patent, and may be consulted by anyone. It is professed that the accuracy of the entries is not guaranteed, yet they are invariably correct. Still, the searcher may, by going to another part of the building, and paying one shilling, see the actual fee register of the Patent Office, about the accuracy of which there is no question, and he may have an official certificate of the currency, or otherwise, of any British patent, by paying a fee of five shillings. This extreme is followed only for legal evidence.

Taking Out a Patent. We may assume that our friend with the safety razor is satisfied that he has not been anticipated, and that he is prepared to take out letters patent. We therefore continue the subject by demonstrating the cost and methods of applying for patent rights in Great Britain and other countries.

Continued

Group 12
MECHANICAL ENGINEERING
10

APPLIED MECHANICS

continued from page 1224

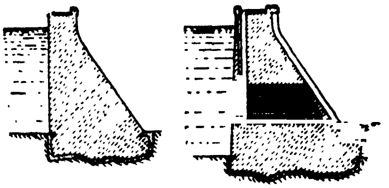
APPLICATIONS OF HYDROSTATICS

The Construction of Dams, Cofferdams, and Caissons. The Use of the Diving Bell. Tanks. The Value of "Head" in Foundry Practice

By JOSEPH G. HORNER

WE have spoken hitherto of the applications of water pressure to the accomplishment of *work*. But there is another aspect of the problem which the engineer has to take account of—namely, to be sure that structures will be able to *resist* the enormous pressures to which so many of them are subjected. The law of liquid pressure is that the pressure varies as the depth, so that its increase is in exact proportion to increase in vertical depth. The engineer, therefore, has to devise means to resist the hydrostatic pressure of water present in large quantities, and with increase in depth those difficulties grow. The most imposing examples are those of dams closing the ends of reservoirs, or barring up the waters of streams. These are among the finest pieces of work in the world. In other cases the structure takes the form of a cofferdam, or of a caisson, both being used to exclude water from areas within which men have to work in the dry.

Dams. Deep water in a quiescent state has enormous pressure. Though we associate force with water in motion, with the breakers, the ocean rollers, and the big tidal waves, these are the *dynamics* of water. But wherever the engineer goes to work far beneath the surface of still water he is confronted with the inexorable laws of hydrostatics. Thus, take the case of a reservoir, or river barrage, the mouth of which is closed by a dam. The finest examples of dams occur at the mouth of the great reservoirs for water supply, and at the barrages of the Nile and other streams where they impound the water of floods for use in dry seasons. These dams are always built of masonry, very broad at the base. Almost invariably they are pierced with openings, having lifting gates or penstocks for the regulation of the flow. An exception occurs at Gileppe, in Belgium, where the dam is absolutely solid, and the impounded waters are led away through pipes at each end of the dam.



158. NILE DAM AT ASSUAN

As the weight of a cubic foot of water is 62½ lb., that represents the weight pressing on a square foot of surface, multiplied by as many feet as the depth of the water. At a depth of 60 ft., therefore, the pressure is 62½ × 60 = 3,750 lb., or a load approaching 1⅔ tons on every square foot. Laterally, the pressure exerted at the bottom is about equal to the perpendicular force. Multiply this pressure by the total length of a dam, and the pressure is enormous. It explains why, when dams have been undermined by water oozing through the foundations, and when the foundations have also sloped away in the direction of the lateral pressure, they have sometimes been swept away, carrying awful destruction and death through the areas below. It explains the enormous thickness of the Gileppe barrage near Spa, 72 yards through at the base. The great Nile dam at Assuan [158] measures 50 and 60 ft. through the base in some parts. Its piers and arches are built on a solid foundation of masonry 10 ft. in thickness and 87 ft. in width, protected by cast-iron piling from all risk of the insidious filtration of water. The piles go down 23 ft. from the surface of the masonry floor into the sand of the river bed. This dam measures rather more than half a mile in length, contains 704,000 cubic yd. of masonry, and required 824,000 cubic yd. of excavation. It cost £2,450,000, was built in three and a half years, and is able to impound 1,000,000,000 tons of water. It is pierced by 180 sluices [shown in right hand figure, 158], which are capable of regulation, and can pass 475,000 cubic ft. of water per second, at a velocity of 20 ft. per second.

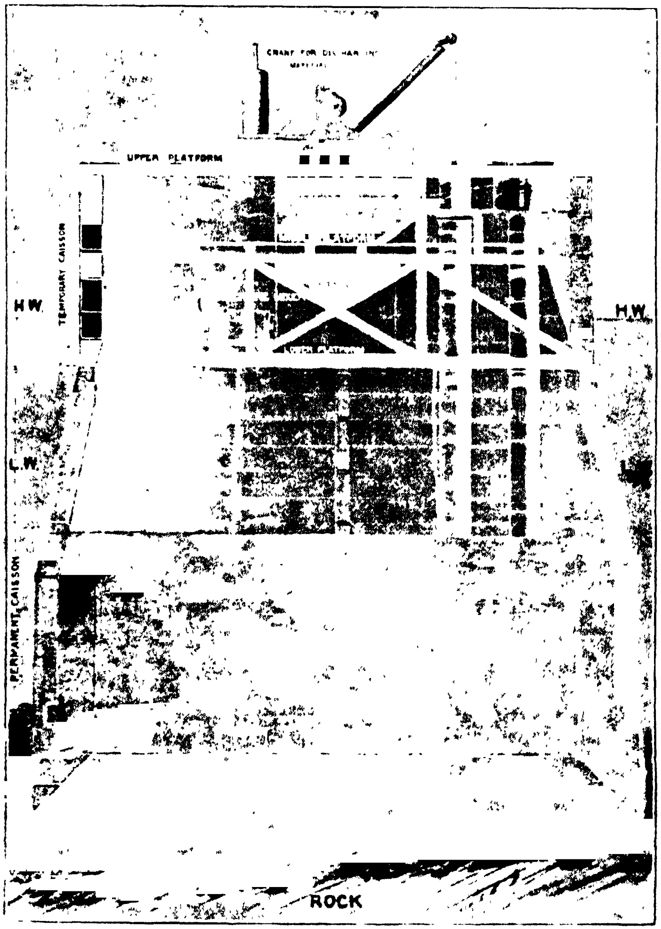
Cofferdams. Take the cofferdams and caissons just mentioned. These are the aids by which the engineer builds deep foundations in running streams and in tidal waters. Diving-bell work excepted, he has to build his foundations in the dry, even though they go down 20, 30, or 40 ft. beneath the bed of the stream. Hence, the cofferdam, or the caisson, is constructed first, enclosing an area from which the water is displaced, leaving it dry and ready for excavation, and for the laying down of masonry or concrete. The differences are, in brief, as follows.

A cofferdam is usually built by piling and puddling. The structure may be round, square, oblong, or prismatic in plan view. In either case, it comprises two sets of piling—that is, there is an inner and an outer ring, or rectangle, or other form built of squared piles, driven in close contact down their sides. Between the inner and outer rows is a space of 3 or 4 ft., which is filled with clay puddle well punned down. Of course, piling involves more than this, as cross bracing with wale pieces, sheet piling, etc., but with these details we are not concerned here. The simple point is the concentric rows of piles, with the puddled space between, by which the water is excluded from the central area, after it has been pumped dry.

This is a simple case, because if deep excavations are required, or, say, those exceeding about 20 ft. in depth, the water would burst through below the piles, and swamp the men and their work. In deep foundations, therefore, the cofferdam gives place to the caisson, which is sunk deeper in stages, as the men excavate deeper. The difficulties here are far greater than those which exist with piled cofferdams.

Caissons. A caisson is a tubular structure usually circular or elliptical, sometimes rectangular and made of steel—though where timber is plentiful, as in America, often of wood. All around its bottom edge there is a sharp steel shoe, which is made to cut its way down into the soil by the weight of the caisson itself, or by extra loading on it. The caisson is made in sections, so that as it sinks deeper, fresh lengths are added above to keep its mouth always above the level of the water. Here, also, there are numerous details on which we cannot touch. But the essential fact to remember is the hydrostatic pressure. This is resisted by making the caisson very strong. Though the steel plates of which it is built do not exceed from ½ in. to ⅝ in. in thickness, they are braced together with diagonal bars to enable them to resist the water pressure surrounding them. Moreover, the lower parts are much stronger than the upper, because the pressure increases with depth.

Deep Caissons. But when caissons go down very deep, it is necessary to counterbalance the pressure of the water by opposing to it that of compressed air. That involves the separation of the working chamber from the atmosphere, and enclosing it completely, and supplying air by pumping into two atmospheres or more. That, again, involves the use of air-tight air locks, with double doors for preventing outrush of air from the chamber, as often as men and materials ascend or descend. Observe **159**, which is a sectional view through the S.E. Inchgarvie caisson of the Forth Bridge. This working in compressed air is very trying, and is the cause of the caisson disease, but it is all due to the pressure of the water at great depths, which, without the counter pressure of the air, would force out the soil from the foot of the caisson, and follow it into the working area. Such accidents have often happened, and men have lost their lives in consequence. The water pressure is ever present to cause anxiety to the engineer, and human foresight cannot always guard against these dangers. For layers of strata of different kinds overlap, and a tough, close clay may exist over a body of sand; or denser and looser gravel and boulders may intermix, and water will find out the weak places, and the only way to prevent its ingress is by counter pressure.

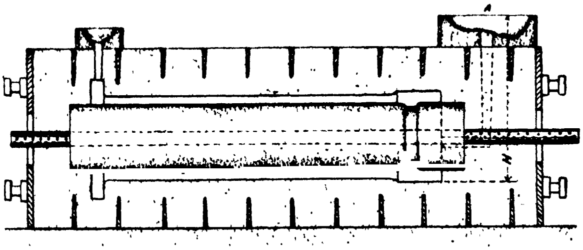


159. INCHGARVIE S.E. CAISSON (Built by Sir Wm. Arrol & Co., Ltd.)

The Diving Bell. The laws of hydrostatics and of pneumatics are often found in mutual operation. We saw that in the sucking pump, and we have noted it in deep caissons. It is also apparent in the diving bell. Down at Dover Harbour and elsewhere you may see huge diving bells at work, preparing submarine foundations for laying concrete blocks on. Men work in an atmosphere of compressed air in the bells, which must be at least equal to that of the water at the depth of the bell, and is actually greater, in order to drive all, or nearly all, the water out of the bell. The air is, of course, pumped in from above.

If we consider a moment, we see that there is no essential difference between the diving bell and the deep caisson having an enclosed working chamber. The closed chamber may be likened to the bell; and, on the other hand, the bell would only need to have a cylindrical tube attached to its roof and coming out above the top of the water, and be fitted with air locks to be in all respects, except details of mechanical construction, identical with a caisson. Even in the diver's dress, water as well as air plays an essential part. It is a question of displacement of water by loading the diver with heavy clothing, without which he could not get to the bottom against the pressure due to the head of water above, which, being much greater than that of the specific gravity of his body, would force him up.

Tanks. Hydrostatic pressure assumes a rather different aspect when tanks of metal are required than in the reservoirs with earthen sides or than with caissons. The device of having wide and well-sloped banks, as in dams, is not available in iron and steel tanks. Yet in many of these, very great pressures have to be sustained. A tank only 36 ft. deep would have over a ton of load on every square foot of its bottom—thus, 36 × 62·5 = 2,250 lb. There are only two materials used in tanks—cast iron and mild steel. The first are made of plates, from 3 to 5 ft. square, bolted together through flanges; the second are built up of sheets riveted together. The cylindrical form is stronger than the rectangular, but is not so readily obtainable in cast iron, so that tanks of this material are made of square or rectangular shape. Several precautions have to be taken, as follows.



160. CASTING-MOULD FOR HYDRAULIC CYLINDER

As the pressure on the bottom is the greatest, and as it is difficult to make plates thick enough for the required strength, one plan is to afford a level support to the bottom, either on girders or beams, or on concrete. This applies to tanks of the largest dimensions made. For those of smaller size, a cast-iron bottom is often made, well ribbed on its lower face, the ribs reinforcing the otherwise flat weak plate, and requiring no other support. Concave, and convex bottoms, and conical bottoms have been proposed, the cambering in either direction affording the required strength; but such forms are neither so readily made, nor so easily supported as flat bottoms are.

The sides of tanks are, of course, subject to greater pressure at the bottom than at the top, and therefore the plates, in the case of deep tanks, are of greater thickness as the depth increases. Thus, if the upper plates in a cast-iron tank are ⅜ in. thick, the lower ones may be ⅝ in. Nor is this sufficient, but the sides are held against pressure by several tie-rods passing right from side to side of the tank and bolted fast thereto. To render tanks watertight, they are caulked. In cast work the flanges only abut by narrow edges, leaving a depth of flange of from 2½ in. to 3¾ in. open, and the space is caulked with rust cement, well stemmed in. Steel tanks are caulked by burring the edges with a caulking tool or chisel, precisely as boiler plates are treated.

Molten Metal. There is another aspect of the subject which concerns liquids other than water. Who has not heard of the fluid compressed steel, the inception of which was due to the late Sir Joseph Whitworth? But that was simply an application of the principle which we have already noted as relating to the difference between a natural head of water and the equivalent of head artificially produced by pressure.

And the foundryman may not neglect this question of head, which is really intensified by the large difference in the specific gravities of water, and of liquid iron, or steel, or brass. He may take advantage of the fact, and by so doing ensure the production of sound, solid castings; or he may neglect it, and find the fluid metal running out of the mould, or the casting being honeycombed with holes.

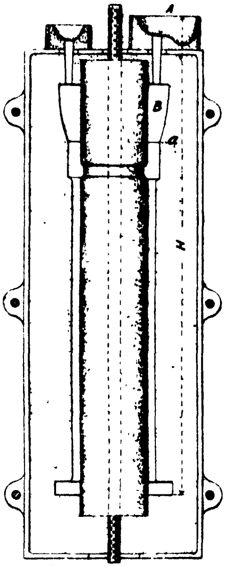
At two extremes, therefore, we have the fluid compression and the natural head. The first is readily understood; the molten steel as it cools and shrinks receives artificial pressure from a hydraulic ram and pump. As shrinkage continues, the pressure is maintained until solidification occurs. The result is that instead of a more or less spongy ingot, from the upper part of which from one-third to one-half the length has to be cut off, to leave only the remainder as suitable for use, practically the whole ingot is solid and sound. Of such stuff guns are made, and propeller shafts, and anything else in which soundness is absolutely essential.

"Head" in the Foundry. In the ordinary work of the foundry, *head* for purposes of pressure is obtained by pouring the metal at some height above the top of the actual casting, and letting it run down into the mould. Engine cylinders which hold steam under pressure, hydraulic cylinders which carry water similarly, pumps also and pump casings, and all work subject to pressure when in service, have special treatment in the foundry, in which advantage is taken of hydrostatic pressure.

To ensure the most satisfactory results the method of casting upright is also often adopted—that is, instead, say, of pouring a cylinder or a ram or pipe with its longitudinal axis lying horizontally, it is poured with the axis in a vertical direction.

Figs. 160 and 161 are sections through two moulds of a hydraulic cylinder, drawn to illustrate these points. Fig. **160** is the mould arranged for casting horizontally. H is the head when the mould is filled with fluid metal. Fig. **161** is the same casting for pouring vertically, and here also H represents the head. The difference is very great, especially when we remember that it is not head of water, but of iron, which is about 7½ times greater than that of water, a cubic foot weighing 450 lb. Supposing that a pipe or cylinder were 9 ft. long, the difference in favour of casting upright due to the difference in length and diameter, would be, say, 8 ft. head at the bottom part of the casting over the horizontal position. And it would not be 8 ft. head of water, merely, but 8 × 7½, representing nearly the specific gravity of iron, or 8½ for bronze, or over 7¾ for steel.

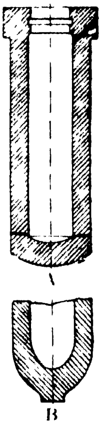
"Dead - head." But more than this is often done. The height of the pouring basin A in the diagrams is often carried up from one to two feet above the top of the casting, with the object of increasing the head. And further, where great soundness is essential, extra length is added above, to be cut off from the actual casting, termed "head-metal" or "dead-head" [B in **161**], the actual length of casting as required when B is cut off terminating at *a*. The height of this addition B is made less or more according to the amount of solidity required in the casting. The writer has often seen as much as from one-fourth to one-third of the finished casting added in the shape of head, to be afterwards cut off and remelted.



161. MOULD FOR HYDRAULIC CYLINDER

This is a utilisation of hydrostatic pressure, but the function of the head is also to receive the dirt and sullage that is liable to get into a mould, and so be entangled in the metal. But, being of less specific gravity than metal, it rises and floats beyond the casting up into the head. Lastly, if one face of a casting is wanted more solid than others, this is ensured, when practicable, by casting that face lowermost, where the pressure is greatest.

Texture of Metal. To those who are unfamiliar with iron and steel, it might seem as though there could be no such thing as porosity and weakness present in them. But, unless the above precautions are observed, iron and steel become so spongy that they will allow the passage of water through the pores when subject to hydrostatic test. This question of closeness of texture of metal, therefore, is a very important one, and a difficult task to secure when very high pressures are in question. On page 1224 mention was made of the hydraulic canal lifts in France and Belgium working to a pressure of 470 lb. per square inch. This is an enormous pressure, considering the size of the cylinders —6 ft. 6¾ in. -- though it would be low for small bores, and could not be sustained by any ordinary cast cylinder. It might be thought that there is no limit to the strength which may be ensured by making the metal in walls very thick. That is not the case, as has been demonstrated in gunmaking. There comes a limit at which increased thickness does not add to strength, and this is the reason why the biggest guns are built up with layers of coiled wire, or by shrinking rings around the body. In the Belgian lift the cylinder, though 4 in. thick, was hooped around with coils of steel 2 in. thick, shrunk on, because it could not have been relied on to resist the pressure without such reinforcement.



162. HYDRAULIC CYLINDER

It is an old story of how the press cylinder fractured during the lifting of the tube of the Britannia Tubular Bridge. The load was 1,144 tons, the cylinder 22 in. bore and 8 in. thick. It fractured at the bottom of the cylinder A [**162**], tearing the end away. The lesson then learned, which has never been forgotten, is not to have a keen angle in a structure subjected to great pressure. The cylinder cast to replace this was made with a nearly hemispherical curve, also shown [B], and it did not break. This form of end is now found on all such types of cylinders for presses.

Continued

Group 6
CIVIL SERVICE
10
MUNICIPAL SERVICE

continued from page 1215

POLICE AND LEGAL POSTS

Positions in the Metropolitan and Provincial Police Forces. Royal Irish Constabulary. Solicitor to Local Authorities

By ERNEST A. CARR

A Familiar Figure. Many of the municipal civil servants whose callings we have discussed are but little known, even by name, to the general public whom they serve. Unlike these, however, the police officer does his duty under the eye of the people. By day and night alike, his blue-clad, helmeted figure is so familiar a feature of our streets and country roads that he needs no introduction to any of us. Nor need we trace the history of police development, interesting though it is, from the ancient system of "hue and cry"—when every man was a peace officer—by way of the city watch satirised by Shakespeare, and the decrepit "Charlies" of the eighteenth century, to the smart and efficient police forces of to-day.

Without more words, then, we may pass to consider the police service as a career. In a work like the present, addressed very largely to students, and to young men who have not yet definitely chosen their calling, special importance naturally attaches to the conditions of entry into the service. We shall therefore seek to show the prospective police officer very clearly what physical and other qualifications are requisite for candidates, and what steps should be taken in order to gain admittance. Other leading features will be the duties and rates of pay in the various grades, the prospects of promotion, and finally the terms on which pensions are granted.

Numbers and Constitution. The police forces of the United Kingdom number in all some 63,000 men—a civil army about as numerous as the medley of British, Belgian, and Hanoverian troops who lined the ridges of Waterloo. Of these officers 46,000 are stationed in England and Wales, and between 11,000 and 12,000 in Ireland. We have termed the police a municipal body, and in the main that description is accurate. If we exclude Ireland, and that part of London which lies outside the City proper, every police force in the Kingdom is under the control of a local authority. They comprise two great divisions—the county and the borough constabulary, the former being controlled by a standing joint committee of the quarter sessions and the County Council, the latter by a special committee—the Watch Committee—of the Borough Council. In the City of London, the Court of Common Council instead of the Watch Committee is the police authority.

To the general rule of municipal control there are but three exceptions. They are very notable ones, consisting of the largest civil forces in the Kingdom—the Metropolitan and Dublin Police, and the Royal Irish Constabulary. The first, although paid largely from municipal sources, is naturally, as the civil power for the capital of the Empire, controlled by the Home Secretary. The Dublin Police owe allegiance to the Chief Secretary for Ireland. The third body—doubtless for old-time political reasons—is under the direction of the Lord-Lieutenant of Ireland. Nevertheless, as police organisation throughout the country is nearly uniform, it is expedient to include these three Imperial forces among their many municipal brethren, so that our police service may be considered as a whole, and within the scope of a single article.

On such questions as the age and height of candidates and the rates of pay for officers of each grade, no fixed scale is operative, each local authority being empowered—within certain limits—to fix the standard for its own force. For the most part these differences are but slight, and the best method of treating our composite subject will probably be to select as typical that largest of all police bodies—the Metropolitan Police Force, distinguishing where necessary between its regulations and those of the City Police and the numerous county and borough forces. The Royal Irish Constabulary, however, as a semi-military body with a special organisation of its own, will be separately considered.

The Metropolitan Police Force. This justly-renowned body, to which is entrusted the unique task of safeguarding the citizens of Greater London, has an area of 700 square miles under its surveillance. As an Imperial force it also furnishes men for duty at the Royal palaces, chief naval bases, and War Office factories and stores. Subject to the supreme control of the Secretary of State, it is directed by a Chief Commissioner and his three assistants. According to the latest available returns, its strength is as follows:

Chief Constables	5
Superintendents	30
Inspectors	535
Sergeants	2,128
Constables	13,990
Total	16,688

Every constable is informed upon enlistment that he may hope to rise by activity, intelligence, and good conduct to the superior grades; and as each position below that of chief constable is filled by the promotion of subordinates, the scope afforded by this democratic service to a zealous and able officer is very considerable.

Conditions of Entry. Every candidate for the Metropolitan Police must be over 21 and under 27 years of age, must stand 5 ft. 9 in.

high (without boots or stockings), and must be free from any bodily complaint, and of a strong constitution. He must further be generally intelligent in the judgment of the officers before whom he presents himself, and must be able to read well, write legibly, and have a fair knowledge of spelling. He cannot be accepted, as a rule, if he has more than two children dependent on him for support.

The bodily complaints for which candidates are most frequently rejected include rupture, flat-foot, varicose veins, tumours, stiffness of the joints, narrow chest, and weak sight.

An application form for this service can be obtained from the Commissioner of Metropolitan Police, New Scotland Yard, S.W., and should be filled in by the would-be constable, in the presence of the chief officer of police for his district, with certain particulars as to his age, character, and calling. The chief officer then measures and certifies the candidate's height and chest development, and the form, thus completed, is returned to the Commissioner's office. If this preliminary inquiry is satisfactory, the candidate receives notice to attend at New Scotland Yard one morning, where his measurements are checked and he is carefully examined by a police surgeon. Having passed this ordeal and given proof of his general fitness for police duty, he is drilled for three weeks in squad exercises and ambulance duty. His period of probation is now at an end. He is sworn in as a police constable, and posted to one of the 22 divisions of the force, where, after a little further instruction in his work, he finds himself at length a constable in earnest.

Police Duty. Metropolitan police constables are required to perform eight hours' duty daily. Night work is always done in an unbroken spell, from 10 p.m. to 6 a.m.; day duty is performed either at a stretch or in two spells of four hours each. The work may be either patrolling a prescribed round (in official parlance, a "beat"), or standing sentinel at a fixed "point." The latter duty sometimes involves "traffic regulation"—the hated task of standing in the carriage-way at a crowded street corner, directing the never-ending cross-tides of traffic. As a rule, the officer is engaged during alternate months on night and day work. The latter is pleasant enough, save in the worst of weather; but the former, with its long, silent hours and its encounters with ruffianism and crime, is both tedious and trying. To secure a savage prisoner single-handed amid a hostile crowd, in "the wee sma' hours ayont the twal," taxes all the novice's courage and skill. But tact and judgment, combined with a fearless bearing, are admirable solvents of the rough practical problems of street duty, whether by day or night, and the young constable soon becomes seasoned to his work.

River and Mounted Police. In addition to ordinary street officers, the Metropolitan Force includes two special branches —the Thames division and the mounted contingent. The river force is recruited entirely from sailors and boatmen, who must be able to swim and skilled in the management of small craft. For the mounted section, preference is given to men who have served in a cavalry regiment, but any officer who is an expert rider and understands horses can apply to enter it after six months' service on foot. Except that the horsemen are required to do 10 hours' duty daily—five in the saddle and five in the stables—both river and mounted officers are subject to the ordinary conditions of the service.

The Road to Promotion. After a few years of steady work in the ranks, a constable who is sober, reliable, and shrewd may look for promotion to the rank of sergeant. The first step towards this object is to obtain his superintendent's recommendation—generally through the kind offices of a friendly inspector. Candidates thus selected are first subjected to a preliminary trial in writing and arithmetic by the station clerk, and those who there acquit themselves passably, and have mastered police squad drill, are "sent up for sergeant."

The first and most trying part of the actual ordeal for promotion is an examination in police duty by a board consisting of a chief constable and four superintendents. The aspirant for the sergeant's stripes is required to make out written reports specifying exactly what steps he would take on a given contingency arising—a fatal fire, an accident to his Majesty's mails, the escape of a prisoner under arrest, or some such emergencies. If his answers show both knowledge of police powers and discretion in wielding them, he is called before the examiners to answer *vivâ voce* a few searching questions based on the "police instruction book"—a formidable manual of police law and practice. Many candidates fail at this stage through nervousness or over-confidence, when an instant's quiet reflection would have saved them.

The survivors undergo a simple examination in writing and spelling, reading and copying manuscript, elementary composition, and the first four rules of arithmetic. Those who pass are then appointed sergeants as vacancies occur.

An intelligent officer is usually afforded two or three chances of "passing for sergeant," but only the specially recommended are promoted without examination.

Inspectorships. For advancement to the grade of inspector a more difficult examination must be taken, the test of police duty being more exacting, and the arithmetic paper including weights and measures, reduction, and vulgar and decimal fractions. A capable, well-educated man, who does his duty with zeal and discretion, and has kept his "defaulter's sheet" clean, should be able to attain an inspectorship without undue delay. But the higher positions available, as sub-divisional and chief inspectors, and as superintendents, are so few and so eagerly contested that further advancement is necessarily slow and uncertain. An examination in English subjects and in advanced knowledge of police duties and administration is prescribed for each rank. Promotion is said to be slowest in the mounted branch.

The C.I.D. The detective branch of the Metropolitan force has its headquarters at New Scotland Yard, and though officially described as the Criminal Investigation Department, it is better known to fame as the C.I.D., or "the Yard." It is specially devoted to the repression of grave crimes, and such as involve elaborate inquiries or present other special difficulties; and if the work of this department scarce realises the sensational descriptions of novelists, it is in sober earnest very responsible and trying, and occasionally dangerous. On the other hand, the absorbing interest of detective duty, the special rates of pay for sergeants and higher officers of this branch, and the chances of personal distinction and valuable rewards, attract to the ranks of the C.I.D. the ablest members of the force.

To become a detective, however, is far from easy. Every officer is individually selected from the uniform staff, and must display in that capacity exceptional shrewdness and resource in dealing with crime ere "the Yard" will open its gates to him. The usual method of selection is to appoint a smart young uniform officer on probation for awhile as a plain-clothes patrol. If he makes good use of this opportunity he is eventually transferred to the detective branch.

Pay, Allowances, and Pension. The various ranks of the Metropolitan Police are paid on the following scale, with increased allowances for special duty at the palaces and elsewhere. Whether calculated on the weekly or yearly pay, the increment is in every case an annual one.

Constables, 25s. 6d., by 1s. a week to 33s. 6d. a week.

Sergeants, 36s., by 1s. to 42s. a week.

Sergeants (detective) in three classes, £2 0s. 6d., by 1s. and 2s. a week to £3 0s. 8d.

Station sergeants and clerk sergeants, £2 7s. 6d., by 1s. to £2 10s. 6d.

Inspectors (divisional), £2 19s., by 2s. to £3 7s.

Inspectors (sub-divisional), £3 13s. 6d. a week.

Inspectors (chief), £4 7s.

Inspectors (detective) in two classes, £3 13s., by 2s. and 4s. to £5 13s.

Chief inspectors (detective), £6 1s., by 4s. to £7 1s. a week.

Superintendents, £320 a year, by £20 to £420 (six receiving £25 a year good service allowance, and one £50).

C.I.D. and other officers employed in plain clothes, are allowed from £10 to £18 5s. a year in lieu of uniform; and, as uniform boots are no longer issued, inspectors receive instead 8½d a week, and sergeants and constables, 6d. Officers of the last two grades, who are not accommodated in the police-station quarters, are entitled to an allowance "in aid of rent," which varies from 1s. 6d. to 4s. a week, according to the district in which they reside. Smart, well-conducted men are eligible for employment in the Houses of Parliament, museums, and Government offices, at an extra 1s. a day; and for special "reserve pay" of 4s. weekly for inspectors, 3s. for sergeants, and 1s. 6d. for constables.

The scale of pensions for the Metropolitan force is a very liberal one; indeed, it is the maximum permitted by statute. Apart from special rates for officers injured on duty, those who are invalided after 15 years' service, or more, receive proportionate life pensions. Further, the ordinary rates permit of retirement *at will*, after 25 years' service, upon $\frac{31}{50}$ths of full pay, or after 26 years at the maximum rate of two-thirds of such pay. Thus, a constable entering the force at the age of 21, and reaching the grade of chief inspector, for example, is entitled to retire at the age of 46 on a life pension of over £135, or at 47 on £150 a year.

City of London Police. This fine body, the admiration of all visitors to the heart of the capital, numbers a thousand men in all. The conditions of recruitment are practically identical with those of the Metropolitan Police, save that the standard of stature is 1 in. higher, the age of admission is lowered to 20 years, and a chest measurement of 36 in. on deflation is essential. The hours of duty are the same; but the City, thronged by day, and well-lit and orderly by night, is a pleasanter patrol-ground than most districts in the Greater London area.

Salaries average higher for subordinate ranks than in the Metropolitan force. Uniform constables, commencing at 27s., rise in six years to 40s. a week, and are eligible, after 15 years' service, for the "merit class," receiving 42s. 6d., whilst detective constables receive from 37s. to 45s. There is, however, no rent-aid allowance. For sergeants in either branch, the maximum is £2 12s. a week. Higher posts are remunerated at about the same rate as outside the City; but the work of the detective staff is relatively less important, and its inspectors are restricted to £3 10s. a week, whereas chief inspectors of the uniform branch attain 30s. more. The City pension scheme permits of retirement after 25 years' service on three-fifths of full pay; but to attain two-thirds, it is necessary to serve for 28 years.

County and Borough Constabulary. The conditions of entrance into the numerous local forces comprised under these two divisions vary a good deal, particularly on the score of age. Some chief constables accept recruits as young as 19 years, and will not enlist them after the age of 25. In Scotland, under a general restriction, police recruits over 25 years of age are not accepted. A good many fix 30 as the maximum, but the average limits are 21 to 26 or 27, with occasional extensions in favour of ex-Army men—who are generally in request for police duty. Candidates who contemplate joining a constabulary force should apply to the local Chief Constable for the regulations of entry.

Many borough, and even county forces, are almost as small as Namgay Doola's army. Several of the former can muster a bare dozen officers for full parades; Louth, Tiverton, Clitheroe, and others—unless they have lately added to their numbers—are below even that modest figure, and (according to an eminent authority on the police service) have not a solitary inspector among them all. Of county forces, Rutland's is least, numbering 15 of all ranks; and Lancashire heads the county list with nearly 1,600 officers. This latter figure, however, is surpassed by Liverpool, which boasts the largest borough force in this country, and one that merits special notice.

The strength of the Liverpool Police Force, according to recent statistics, is 1,884 men (including 10 superintendents and 69 inspectors), and comprises a river force, a police fire brigade, and a small mounted contingent. Excluding the Chief Constable and his deputy, the rates of pay are:

Constables, 25s. to 33s. a week.
Sergeants, 36s. to 42s. a week.
Inspectors, £115 to £165 yearly.
Chief Inspectors, £165 to £215.
Superintendents, £240 to £420.
Chief Clerk (a police officer), £450 yearly.

The pension scheme is on the same liberal footing as in the Metropolitan force, and there is a "merit class" for sergeants and constables, carrying extra pay.

The Transfer Clause. In county forces, and those of the smaller boroughs, the general level of salaries is somewhat smaller than at Liverpool. Constables' pay sometimes starts at as little as a guinea a week, and for higher grades the average rates are approximately as follows: Sergeants, 32s. to 37s. a week; inspectors, £100 to £130 a year; and superintendents, between £140 and £220. Further, many minor police forces, owing to the scarcity of higher positions, offer practically no prospects of promotion. Fortunately, however, there is a valuable provision in the Police Act of 1890, which enables an ambitious officer who finds himself so unfortunately placed, to transfer, under certain conditions, to a more promising force, without forfeiting the service he has already rendered towards a pension. Under section 4, clause 4, of that Act, "an officer's approved service of not less than three years in any police force in the Kingdom, shall be reckoned as service in any other such force to which, with the written consent of his chief officer, he may remove."

The Chief Constable. The premier position of chief or head constable, in a county or borough force of any magnitude, is a valuable one, commanding an income of from £400 to £600 a year, and often considerably more. At Birmingham, Sheffield, and the West Riding the salary is £800, at Manchester £1,000, and at Liverpool £1,400 a year. These posts are rarely filled by direct promotion. Some are held by able officers from the Metropolitan force, and others by retired officers of the Army and Navy, and ex-inspectors of the Royal Irish Constabulary.

With regard to pensions, the majority of police authorities have adopted the maximum scale which, as already explained, prevails in the Metropolitan force. A number of them, however, instead of sanctioning voluntary retirement after 25 or 26 years' service irrespective of age, require officers to remain in the ranks until they are 50 or 55 years old, unless invalided earlier.

In Scotland, 34 years' service is requisite to secure the full pension of two-thirds of pay. Lists of the pay and pension scales of the many county and borough forces, with much other useful information, will be found in Mr. Stanley Savill's unique work on "The Police Service," published at 69, Great Queen Street, W.C.

Irish Police Forces. In lieu of a multiplicity of small forces, Ireland has two important ones—the Dublin Metropolitan Police in the capital, and the Royal Irish Constabulary throughout the country. The former, some 1,300 strong, is based on the model of its London namesake, but with certain differences. Candidates must be between 20 and 26 years of age, of "a reasonable degree of education," and with some knowledge of grammar and arithmetic. Each must also present testimonials from a magistrate or clergyman, and must own £1 for necessaries on joining. The pay of constables rises from 23s. to 30s. a week, that of a sergeant from 34s. to 38s., of an inspector from £120 to £160 per annum, and a superintendent from £250 to £320. All the upper grades are filled by promotion from the ranks.

Royal Irish Constabulary. This notable body is practically a civil army of 10,500 officers and men. R.I.C. troops are housed in barracks, and trained to the use of arms; their drill and duties are semi-military at least, and their officers—as in the Army—are drawn from a class quite distinct from that of the rank and file.

Constables. Candidates for this service must be between 19 and 27 years of age, of good health and character, and unmarried. The minimum height is 5 ft. 9 in., and the chest development must be 36 in. at least. Sons of members or of pensioners of the force are admitted at 18 years if they are well-built and stand 5 ft. 8 in. or more. Before admission, all candidates are examined in reading, writing, and the first four simple rules of arithmetic.

In addition to barrack-room accommodation and rations on the military scale, the pay of recruits is £39 a year. On completion of six months' service this becomes £54 12s., with allowances, and afterwards rises by increments of £2 12s. every three years (approximately) to £70 4s., the maximum pay for constables. Sergeants receive from £75 8s. to £80 12s., and head constables from £91 to £104 a year. Prospects of promotion beyond this grade are very scanty. A pension of three-fifths pay may be claimed after 25 years' service.

Officers. Cadetships in the R.I.C. are awarded—usually to the number of eight or ten each year—on the result of competitions limited to candidates who have been nominated by the Lord-Lieutenant of Ireland. A minimum height of 5 ft. 8 in. is essential, as well as good sight and hearing, and a sound constitution. Details of the examination are given in the schedule on next page.

ROYAL IRISH CONSTABULARY CADET COMPETITIONS

Examining Body, Time and Place of Examination.	Subjects of Examination.	Fee and Age Limits.
Civil Service Commission. As required: Usually once each year. Dublin.	English Subjects: Arithmetic, Spelling, Handwriting, English Composition and Correspondence, Geography (especially British Isles), and British History (including Constitutional). Digest of Returns into Summaries. Précis. Latin or French. Principles of Law. Law of Evidence. Reading aloud (print and MS.). Note. There is an oral examination in French. All candidates must be nominated by Lord-Lieutenant of Ireland.	£2. 21 to 26 years. (19 to 26 for sons of Constabulary officers: 21 to 28 for officers of Army, Navy, or Police in certain instances.)

There are also special competitions limited to the sons of constabulary officers.

A successful candidate, while undergoing his cadet's course of instruction, must be provided with a small allowance to supplement his pay; and on being appointed third-class inspector, the cost of his outfit, which varies between £40 and £60, must also be defrayed.

The salaries of the Royal Irish Constabulary officers are as follow:

District inspectors (3rd class), £125; (2nd class), £165 to £180; (1st class), £225 to £300.

County inspectors, £350 to £450.

Town inspector, £600; and a few higher posts.

Advancement to the second class is generally speedy. In each grade a certain number of officers receive good-service pay.

The duties of the Royal Irish Constabulary have included in the past a great deal of distressing and distasteful work, but now that agrarian outrages on the one hand, and evictions on the other, are virtually unknown, the conditions of the service are greatly improved. It is plain that its monetary prospects—whether from the view point of the officers or their men—are not strikingly brilliant. Nevertheless, the outdoor life, and the soldierly character of the force, have always attracted a considerable number of applicants for posts in each grade.

Having completed our review of the police services, we may here add a brief reference to legal posts under the municipal authorities, other than the town-clerkships discussed on page 989.

Solicitors to Local Authorities. "The legal branch of the corporation will always offer good positions for men of brains, good address, and administrative capacity," writes a leading municipal officer of wide experience. Such posts, indeed, are often very valuable. The solicitor to the City of London receives £2,500 a year, and his legal colleague, the comptroller, £500 less. The remuneration of the solicitor and deputy clerk to the London County Council, who was formerly its parliamentary agent, commences at £1,200, and rises to £1,500 a year. In the metropolitan boroughs and larger towns the appointment of solicitor to the council is of an average value of at least £750 a year, and often reaches nearly twice that figure, without restriction as to private business. These latter positions, however, are jealously retained, for the most part, by solicitors of established practice and of considerable local influence, and are therefore attainable only by partnership or succession. Easier of access for the young lawyer without influence is the post of assistant solicitor under a leading authority, such as is occasionally advertised in the municipal press. These positions are often of considerable value. Under the great London councils they are remunerated with £1,000 a year, whilst Manchester pays £450 and Newcastle £400. Further, they involve (as we saw in the case of the appointment under the Bradford Corporation already quoted in the Town Clerk's section) a useful variety of duties, on the strength of which a good many assistant solicitors obtain lucrative town-clerkships.

Other Legal Posts. Omitting High Court and police-court appointments, which belong to the National Section, there remain a host of other municipal offices available only to a solicitor or to "counsel learned in the law." They range through the whole gamut of dignities, from the Recorder of London, with his knighthood and £4,000 a year, down to the clerk of indictments on a judge's circuit, earning as many hundreds. The intermediate grades are occupied by county court judges (£1,500 to £2,500), registrars (about £800 to £1,000), and minor clerks of the peace, etc., at all salaries. But such posts as these are in their nature legal rather than municipal; they are available only to lawyers of standing, and, moreover, are seldom (if ever) definitely pursued by aspirants from the outset of their professional life. They are dependent on the myriad uncertainties of a legal career—on the practitioner's reputation in his profession, his local opportunities, peculiar gifts or influential friendships, and much else which might fitly be included in a compendious guide to the law, but which would be out of place in a Civil Service course.

Continued

PRACTICAL GEOMETRY

Continued from page 1255

Reducing and Enlarging Figures. Miscellaneous Plane Curves. Describing an Ellipse, Parabola, Hyperbola, and Cycloidal Curves

By WILLIAM R. COPE

Reducing and Enlarging Figures.

373 [p. 1255]. To Reduce a Given Irregular Figure *ABCDEFG* to a Similar One whose Sides shall be, say, Three-Fifths of those of the Given Figure. Divide the figure into triangles by the lines *BD*, *BE*, *BF*, and *BG*, drawn from *B*, one of the corners. From *B*, along *BC*, set off *Bc*, equal to three-fifths of *BC*, and through *c* draw *cd* parallel to *CD*, cutting *BD* in *d*. Complete the figure *aBcdefg* by a series of parallels, as shown.

Note. Complicated figures may be reduced or enlarged by the use of squares, as explained in problem **116**.

374 [p. 1255]. To Find the Area of a Figure Bounded by Three Rectangular Lines and an Irregular Curved Line, as *ABCD*. Draw a straight line *AD* through the curve, so that *AD* becomes a give-and-take line—that is, so that it cuts off as much as it adds to the figure. Then draw *AE* parallel to *BC*, cutting *CD* in *E*. The area of *ABCD* is then equal to $(AB \times BC) + (AE \times \frac{DE}{2})$.

375 [p. 1255]. To Find the Approximate Area in Acres of a Field Represented by an Irregular Curved Line, as Shown. The area could be found by the method used in the preceding problem [**374**]; but surveyors often use a method of setting out a series of parallel lines (on the plan of the field) a certain distance apart, according to scale. If the scale is 3 chains to 1 in., then the distance apart of the parallels $= \frac{10}{3^2} = \frac{10}{9} = 1\frac{1}{9}$ in. (The numerator 10 is taken because there are 10 square chains in an acre.) The parallels are thus drawn $1\frac{1}{9}$ in. apart. Perpendiculars are drawn at the ends in a give-and-take way. Then every *inch in length* of the strips, which are $1\frac{1}{9}$ in. wide, represents an acre.

Miscellaneous Plane Curves. There are curves which cannot be drawn by the ordinary compasses, therefore a number of points are found first, and the curve is then drawn freehand or with the aid of French curves, through these points.

When a right cone is intersected by planes in various directions, the intersections give what are known as the *conic sections*. They are, as in **376**, the *circle*, when the plane is perpendicular to the axis, or parallel to the base of the cone; the *ellipse*, when the plane is inclined, and passes through opposite sides of the cone; the *parabola*, when the plane is parallel to the generator *CD* [**376**] of the cone; the *hyperbola*, when the plane is so inclined that its angle with the axis *AB* is *less* than that made with the generator [**376**].

The cone is supposed to be generated thus: *AB* is a fixed *axis*, and *CD*, the *generator*, is a straight line intersecting *AB* at *V*, the *vertex*. *CD* is then revolved around *AB*, at a constant angle with *AB*, thus generating the surface of a right circular cone [**376**].

The Ellipse. An ellipse has two *foci*, *F* and *f* in **377**, and two *directrices*, *EG* and *HJ*. The line *AB* is called the *transverse* or *major axis*, and *CD* the *conjugate* or *minor axis*; these axes are perpendicular to each other. A line drawn through the centre *O* and terminated both ends by the curve of the ellipse is a *diameter*, as *KL*. Any straight line perpendicular to the major axis is called an *ordinate*, as *mn*, and *mp* is a *double ordinate*. A *tangent* is a line, as *MN*, which touches the curve in one point, and a *normal* is a perpendicular, as *PQ*, to a tangent at the point of contact. It should be remembered that if any point in the curve of the ellipse be joined to the foci by two straight lines, such as *FC* and *Cf*, or *FL* and *Lf*, these two lines are together equal to the major axis *AB*.

377. To Describe an Ellipse, the Major (*AB*) and Minor (*CD*) Axes being Given. First Method, by Means of a Piece of Thread. Place the two axes so that they are perpendicular to and bisect each other at *O*. With radius *AO* (half the major axis), and centre *C*, describe an arc cutting *AB* in *F* and *f*, which are the foci. Place three pins, one at each of the points *F*, *C*, and *f*, and tie a piece of thread round *F*, let it pass round *C*, and tie again round *f*. Remove the pin at *C*, and replace it with a pencil. Move the point of the pencil round, keeping the thread taut all the time, and the curve thus described is the ellipse.

378. The Same. Second Method, by Intersecting Arcs. Place the axes and find the foci as before. In *FO* take any number of points as 1, 2, 3. (It is better to make the distances 1 2, 2 3, 3 *O*, unequal, with the smallest division next to *F*, as shown.) With radius *A*1 and centres *F* and *f*, describe four arcs at *e*. With *B*1 as radius and the same centres, intersect these arcs at *e*. With radius *A*2 and the same centres, describe four arcs at *g*, and with radius *B*2 and the same centres, intersect these arcs at *g*. With radius *A*3 and centres *F* and *f*, describe four arcs at *h*, and with radius *B*3 intersect them at *h*. Draw the ellipse through the points *e*, *g*, *h*, *A*, *D*, *B*, and *C*.

379. The Same. Third Method, by Intersecting Lines. Place the axes as before, and through their extremities draw parallels to the axes, making a rectangle *EFGH*. Divide *AE* into any number of equal parts (say four), and join each of these points with *C*. Divide *AO* into the same number of equal parts, and from *D* draw lines through 1, 2, 3, and 4, to intersect those from *C*. Through the respective points of intersection draw the curve *AC*. Proceed in the same manner, as shown, with the other three quarters of the ellipse.

380. The Same. Fourth Method, by Means of a Straight Edge, or Paper Trammel. Place the axes as before. Take a piece of paper, or long flat ruler if the ellipse be large, and make *EF* equal to *AO*, and *EG* equal to *CO*. Place it—the trammel—so that *F* is on the minor axis, and *G* on the major axis. *E* is then a point on the curve. Any number of points may thus be found, being careful always to keep *F* on the minor and *G* on the major axis. Draw the ellipse through the points thus obtained.

381. To Describe an Ellipse Passing Through any Three Points *A*, *B*, *C*, not in the Same Straight Line. Join *A* and *B* and bisect in *O*. Join *CO*, and produce, making *OD* equal to *CO*. Draw parallels to *AB* through *C* and *D*, and to *CD* through *A* and *B*, thus forming a parallelogram. Proceed as in problem **379**.

382. To Find the Centre, Axes, and Foci of a Given Ellipse. Draw any two parallel chords *EF* and *GH*, and bisect them in *J* and *K*. A line through *J* and *K*, and terminated by the curve, is a diameter. Bisect it in *O*. With *O* as centre, and any convenient radius, describe an arc cutting the ellipse in *L*, *M*, and *N*. Join *L* and *M*, and *M* and *N*. Through *O* draw parallels *AB* and *CD* to *LM* and *MN* respectively. *AB* and *CD* are the axes. The foci [*F* and *f*] are found as in **377**.

383. To Draw a Tangent and a Normal to an Ellipse from a Given Point *E* in the Curve. Find the axes and foci as in **382**. Join the foci with *E* and produce *FE* and *fE*. Bisect the angle *FEG* by the line *HJ*, which is the tangent. For the normal, draw a perpendicular, *KE*, to the tangent. Or, bisect the angle *GEL* by the line *KE* which is the normal.

The Parabola. This curve is the locus of a point which moves so that its distance from the focus [*F*, in **384**] always equals its distance from the fixed line called the directrix, *DD*. Thus *Fa* = *aL*, or *Fc* = *cM*. In **384**, *AB* is the *axis*, a line drawn through the *focus F*, perpendicular to the *directrix DD*, and meeting the curve in the point *V*, which is the *vertex*. *a*1, *c*2, etc., are *ordinates*; *aa'*, *cc'*, etc., are *double ordinates*; and *bb'* (through the focus) is the *latus rectum*. A part of the axis between the ordinate of a point and the vertex of the curve is the *abscissa*—*e.g.*, 3*V* is the abscissa of the point *d*.

384. To Draw a Parabola, the Focus *F* and the Directrix *DD* being Given. Through *F* draw the axis *AB* perpendicular to *DD*. Bisect *AF* in *V*, which is the vertex of the curve. Take any points 1, *F*, 2, 3, 4, etc., and through them draw the ordinates. With *F* as centre and radius *A*1 cut the ordinate in *a* and *a'*. With radius *AF*, and again the focus as centre, cut the ordinate through *F* in *b* and *b'*. With *F* as centre again, and radius *A*2, cut the ordinate through 2 in *c* and *c'*. Proceed in the same manner with any other points. Draw the parabolic curve through the points.

384a. To Draw a Tangent and a Normal from a Given Point *P* in the Curve. Join *P* with the focus *F* [see **384**], and draw *PE* parallel to *AB*. Bisect the angle *EPF* by *HG*, which is the tangent. *PJ* a perpendicular to *HG* is the normal.

385. To Draw a Parabola, when the Axis *AB* and an Ordinate *BC* are Given. Produce *CB* to *D* and make *BD* equal to *CB*. Construct the rectangle *CDFE*. Divide *AE* and *EC* into the same number of equal parts (say three). Join *A* to 1 and 2 in *EC*. From 1 and 2 in *AE* draw parallels to *AB* intersecting the other lines. Through the points of intersection draw the curve *CA*. Repeat the method for the other part of the curve, as shown.

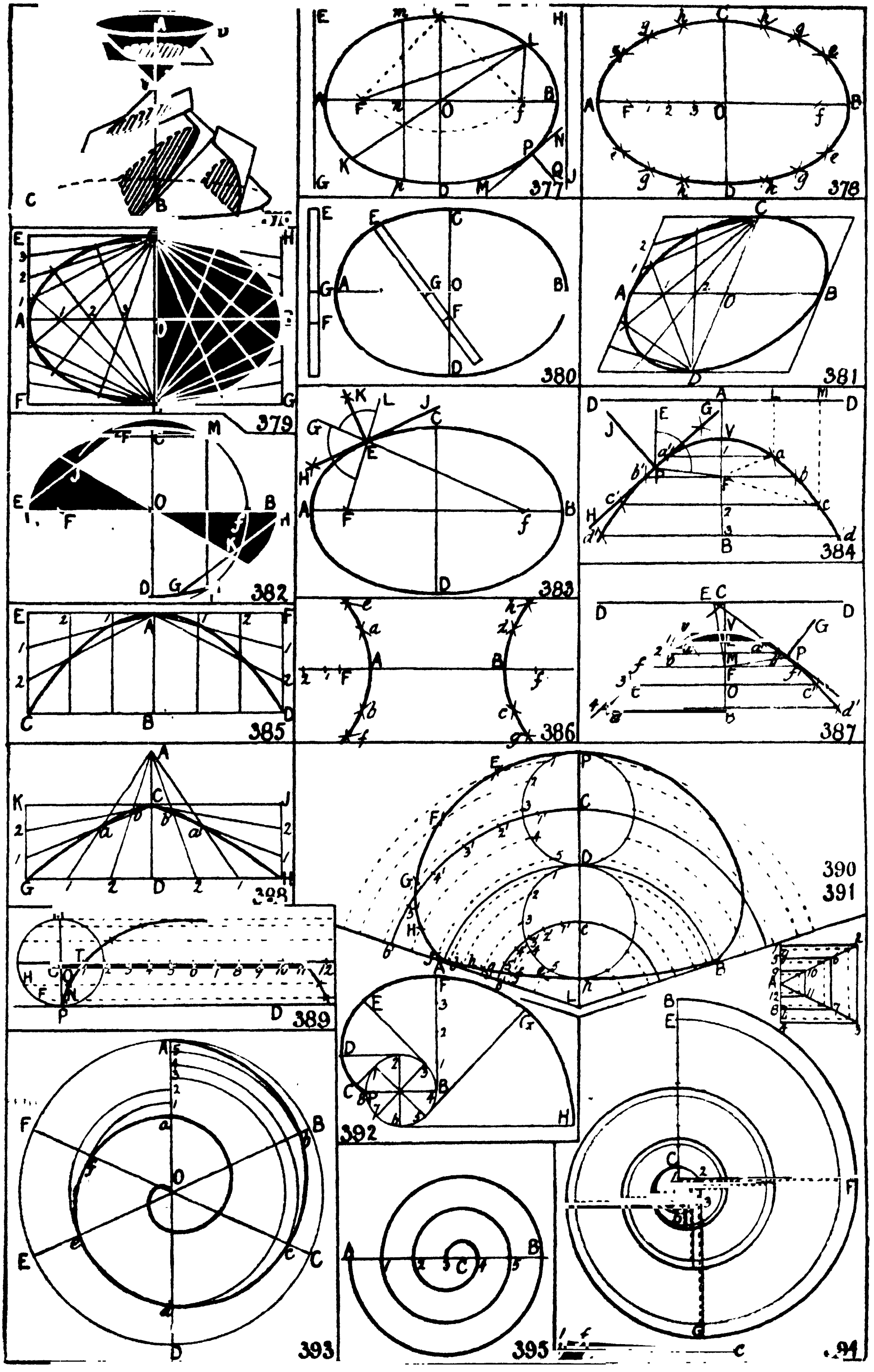
The Hyperbola. This curve is the locus of a point which moves so that its distance from the focus bears a constant ratio (greater than unity) to its distance from the directrix.

386. To Draw the Hyperbola, when the Major Axis *AB* and the Foci *F* and *f* are Given. In *AB* produced, and beyond *F*, take any number of points, 1, 2, 3, etc. (It is better gradually to increase the distance between the points, as shown.) With centres *F* and *f* and radius *A*1 describe arcs at *a*, *b*, *c*, and *d*. From the same centres, with radius *B*1, intersect the other arcs at *a*, *b*, *c*, and *d*. With centres *F* and *f* and radius *A*2 describe arcs at *e*, *f*, *g*, and *h*, and intersect them with radius *B*2 from the same centres. Proceed likewise with the radii *A*3 and *B*3. Draw the curve through the points of intersection.

387. To Describe the Hyperbola, having Given the Focus *F*, the Directrix *DD*, and the Vertex *V*. And at a Point, *P*, in the Curve to Draw a Normal and a Tangent. Join *FV* and produce both ways. Draw *Vv* perpendicular to *CB* and equal to *VF*. Draw *Cv* and produce. On *VB* take any points *L*, *M*, *F*, *O*, etc., and through them draw the double ordinates perpendicular to *VB*, meeting *Cv* in 1, 2, *f*, 3, etc. With centre *F* and radius *L*1 cut the double ordinate through *L* in *a*, *a'*. With same centre and radius *M*2 cut the double ordinate through *M* in *b*, *b'*. Proceed similarly for the other points *f*, *f'*, *c*, *c'*, *d*, *d'*. Through these points draw the curve.

For the tangent, join *F* with the point *P*. Draw *FE* perpendicular to *PF*, and intersecting the directrix in *E*. Draw *EP*, the required tangent. The normal is *PG*, perpendicular to the tangent.

388. To Draw the Hyperbola, having Given *AC*, half the Major Axis, *GH*, a Double Ordinate, and *CD*, the Abscissa of the Point *G* or *H*. Draw the rectangle *GHJK* about *CD* and *GH*. Divide *GD*, *HD*, *HJ*, and *GK* into any number (say three) of equal parts, and number the parts as shown. From *A* draw



CONSTRUCTION OF ELLIPSE, PARABOLA, HYPERBOLA, CYCLOIDAL CURVES, SPIRALS, AND IONIC VOLUTE lines to the points on *GH*, and from *C* lines to the points on *GK* and *HJ*. The intersections of *C*1 with *A*1 give the points *a* and *a′*, and the other respective intersections give the other points *b*, *b′*, through which the curve is drawn.

Cycloidal Curves. A *cycloid* is the locus of a point on the circumference of a circle, which rolls along a straight line, and always revolves in the same plane.

The *epicycloid* is the locus of a point on the circumference of a circle, which rolls along the *outside* of another circle, both circles remaining in the same plane.

When the circle rolls along the *inside* of another circle, both keeping in the same plane, the curve traced by the point is called the *hypocycloid*.

The moving circle is the *generating circle*; the line upon which it rolls is the *director*; and the point tracing the curve is the *generator*.

389. TO DRAW THE CYCLOID OF THE POINT *P* IN THE GENERATING CIRCLE *PHM*, WHICH ROLLS ALONG THE DIRECTOR *PD*. Divide the circumference into any number of equal parts (say 12). Through the divisions draw parallels to *PD*, and make the one through *C* (the centre of the circle) equal to the circumference of the circle. Divide this parallel into 12 equal parts. With 1 as centre and radius *CP*, cut the parallel through *F* in *N*. With same radius and centre 2 cut the parallel through *H* in *O*. Repeat the method with 3, 4, 5, 6, etc., as centres. Draw the cycloid through the points *P*, *N*, *O*, *T*, etc.

NOTE. If the point (generator) is not in the circumference of the circle, the locus is termed a *trochoid*, and is found in the same manner as the cycloid.

390. TO DRAW THE EPICYCLOID, THE DIRECTOR *ADB* AND THE GENERATING CIRCLE, THE POINT *P* BEING GIVEN. Divide the circumference into any number of equal parts (say 12). Join *L*, the centre of the director arc *ADB*, with *D*, the point where the director touches the generating circle, and produce to *P*. *DP* is the diameter of the generating circle. Measure the arc *DA* equal to half the circumference of the generating circle; this is best done as follows: The angle *DLA* bears the same ratio to 180° as the radius of the generating circle does to the radius of the director. Thus, if $DC = 2$, and $LD = 5$, the angle $DLA : 180° :: 2 : 5$—*i.e.*, $5DLA = 360°$, or $DLA = 72°$. Draw *LA* making 72° with *LD* and produce. With centre *L* describe an arc through *C*. This arc is the path of the centre of the circle when rolling, and 6′ is the position of the centre when *P* reaches *A*. Divide *C*6′ into six equal parts, 1′, 2′, 3′, etc. With centre *L* describe arcs from 1, 2, 3, etc. From centre 1′ with radius *CD* cut the arc from 1 in *E*. From centre 2′ and same radius cut the arc from 2 in *F*. Proceed similarly for the other points *G*, *H*, and *J*, and also for the other half of the curve, which is to be drawn through the points *A*, *J*, *H*, *G*, *F*, *E*, etc.

391. TO DRAW THE HYPOCYCLOID WHEN THE DIRECTOR *ADB* AND THE GENERATING CIRCLE *Dp* ARE GIVEN. Proceed exactly as in the preceding problem. Draw the half curve *Ap* through the points *e*, *f*, *g*, *h*, *j*, and *A*.

Miscellaneous Spirals. The *involute* of a circle is the locus of the extremity of a perfectly flexible thread unwound from a circle and kept constantly taut.

392. TO DRAW THE INVOLUTE OF A CIRCLE. Divide the circle into any number of equal parts (say eight). At the extremity of each radius draw a *tangent to the circle*, and make the one *BF* from *B* equal to half the circumference of the circle. Divide *BF* into four equal parts. Make $1C = B1$, $2D = B2$, and $3E = B3$. Draw the curve through the points *P*, *C*, *D*, *E*, etc.

393. TO DRAW AN ARCHIMEDEAN SPIRAL, THE LONGEST RADIUS, *OA*, AND THE NUMBER (SAY TWO) OF CONVOLUTIONS BEING GIVEN. Describe a circle with radius *OA*. Divide *OA* into as many equal parts as convolutions required (two). Divide the circle into any number of equal parts (say six), and draw the radii, *OB*, *OC*, etc. Divide *Aa* into the same number of equal parts (six). Make $Ob = O5$, $Oc = O4$, $Od = O3$, etc. Draw the first convolution through the points *A*, *b*, *c*, *d*, *e*, *f*, *a*. The second convolution is parallel to the first.

394. TO DRAW THE IONIC VOLUTE, THE CATHETUS, OR GREATEST RADIUS, *AB*, BEING GIVEN. (GOLDMAN'S METHOD.) Divide *AB* into *nine* equal parts. With centre *A* and radius equal to one equal part describe the circle for the eye *CD*. Bisect *AC* and *AD* in 1 and 4, and construct the square 1 2 3 4. [See smaller figure.] Join *A*2 and *A*3, and trisect *A*2 and *A*3 with great care. Through the points of trisection 6, 7, 10, 11, draw lines to obtain the smaller squares, 5 6 7 8 and 9 10 11 12. With centre 1 and radius 1*B* describe the first quadrant to meet 1 2 produced in *F*. With centre 2 and radius 2*F* describe the second quadrant to meet 2 3 produced in *G*. Proceed in like manner for the other quadrants, being careful to take the centres successively as figured. An enlarged drawing of the construction is given.

The inner curve is obtained thus: Make $cb = CB$, and the perpendicular $b1 = A1$. Join *c* and 1. Make $be = BE$, and at *e* draw the perpendicular *ef*. From *A* (above and below), set off *Ag* and *Ah* each equal to *ef*, and construct the dotted square. Trisect as before for the smaller dotted squares, the corners of which are the centres for each quadrant of the inner curve.

395. TO DRAW A SPIRAL SCROLL BY MEANS OF SEMICIRCULAR ARCS, HAVING GIVEN THE GREATEST DIAMETER *AB* AND THE NUMBER OF CONVOLUTIONS (SAY THREE). Divide *AB* into six equal parts in 1, 2, 3, 4, and 5. Bisect 3 4 in *C*. With centre *C* and radius *C*3 or *C*4 describe a semicircle. With centre 3 and radius 2 3 make another semicircle. Then with *C* and 3 as centres alternately, and radii *C*2, *C*1, and 3 1, 3*A*, respectively and alternately, describe the remaining semicircles

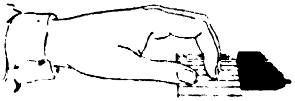
Continued

HOW TO PRODUCE SOUND

Correct Position of the Hands—continued. How to Depress the Keys. Exercises. Sustained Tones. Resting. Tone-quality

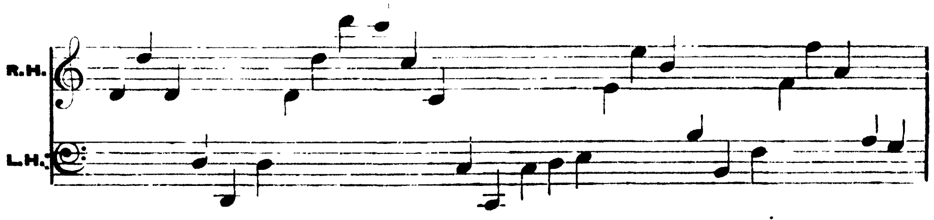
By M. KENNEDY-FRASER

VE shall try now to rest the hand on the keys in the *position* of 6 [page 1212], but in the *ndition* suggested by 5, remembering always iat the condition is the essential thing. To get is we must try carrying the loosely hanging and to the keyboard by a movement of the rm, lowering it till the finger-tips touch the eys, and then continue this gentle lowering f arm till the forearm, wrist, and knuckles rm almost a straight line, the knuckles standing ıst a little higher than the wrist by reason of ıe *very* gentle, yet firm, standing-up action n the part of the fingers.



7.

For the first esson, then, lternate the tudy of the hanging hand with hat of finding eys quickly and urely all over the keyboard; and, as soon s possible, *combine* the two, carrying the ose hand up and down the keyboard in bedience to the eye, which picks out the otes. As we do so, let the *arm* invariably lace the finger-tip over its key, the hand aking no *active* part. We shall take single otes thus, but shall not read from the paper, eeping the eyes rather for watching the arm, and, fingers, and keyboard.



Pick out thus, D's, C's, E's, B's, F's, A's, nd G's. Let the hand hang limp from the arm; arry it about like a flail. When the finger-ip touches its note, let the forearm at the wrist escend to the normal playing position [7]. Lift he hand again by means of the arm, the finger-ip being loth to leave the key, and so *da capo* all ver the keyboard. We may find it easier to ork for a while with one hand and arm, then, esting this completely, continue the experiment with the other.

Knowledge of the Arm. The pianist must know his arm as intimately as he knows is instrument. The arm is jointed, and we can ork its different portions singly or together. t has four joints. (1) Upper Arm (shoulder o elbow); (2) Forearm (elbow to wrist); 3) Hand (wrist to knuckles); and (4) Fingers. These are, again, jointed in three portions; but we shall, in the meantime, treat them as one.

These four portions of the arm can either support their own weight or hang limply; or they can, together and separately, be exercised downwards. The muscles that serve to lift or support them are distinct, or *opposite*, from those that lower them, and if the two sets are unnecessarily employed *together*, they become "opposing" muscles. We will call the lifting muscles the "up" muscles. When we wish either to lower or to let fall a limb (or part of a limb), or to exert it downwards, we must *not* use the *opposite*, or "up," muscles. If we let the hand hang quite loosely from the end of the arm [5], we have *relaxed* the *up* muscles of the hand.

Curved Line of Finger-tips. Now let us drop the hand in this way over the keys. Then gently lowering the whole arm, the longest fingers will first come into contact with the ivories, and will curve slightly palmwards as the wrist continues to descend. When all five fingers have reached the keys, we shall find that their tips form quite naturally a crescent curve. And if the fingers are properly doing their supporting work, fingers and hand together will form an arched dome over the keys.

The Knuckles. As we have seen, the five fingers on the five keys gently support the weight of the loosely hanging hand. We know that to do this *they must be slightly active*—active enough to cause the knuckle at the junction of finger and hand to protrude slightly upwards, rather than sink in. It is important to remember that *none* of the finger-knuckles should be permitted to sink in, neither the hand-knuckles, nor those nearest to the finger-tips. Bending the latter inwards is a common fault with beginners, and one which must be carefully guarded against and corrected.

The mere weight of the hand, supported by a very slight bracing up of the fingers, is insufficient to weigh down the ivory end of the see-saws, and so the hand may rest thus on the surface of the keys, without overbalancing them. This must be practised daily, resting on the surface of key with limply hanging hand. The student would find it a great help to get a second person frequently to toss up the forearm of the player just at the wrist. The tips of the fingers would remain *resting* on the keys, to make sure that the hand was still left *hanging* free from the forearm, and had not locked itself—like the locking of the front wheel of a bicycle—into the condition prohibited, as in 6. If this assistance is not available, the student should, just as a preparatory experiment, toss up the arm with the free hand.

Silent Keyboard Practice. And now, with the limp hand supported by the fingers resting on the ivory ends of the see-saws (but still not depressing them), the forearm, at the wrist-joint, should be swung gently up and down (without any help from the other hand), care being taken that the gentle resting weight on the keys, borne up from the tips of the fingers to the knuckles, is still felt. This *bearing-up* sensation in finger action is one that we must *never*, in all our playing experience, forget.

Matthay says: "The sensation accompanying all correct touch is that of work done upwards. In walking, standing, or running, you have a similar effect. It is true that your feet press upon the ground, but the exertion is *upwards*. And the moment you feel, at the piano, as if you were acting downwards, you may be sure you are employing the wrong exertions."

The second important maxim to be remembered is that the hand hangs loosely from the forearm, but it and the fingers may *bear upwards* by reaction from the keys.

The Key as Extension of the Finger. Matthay says: "The key is but a machine-lever, handle, or tool, to enable us to create speed in the string—an intimate elongation of our body."

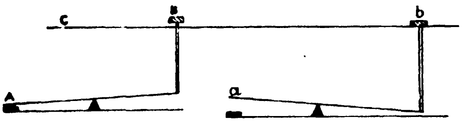
We have, so far, likened the key to a see-saw. Let us now use additional similes, and liken it to, say, a tennis racket, a cricket bat, or a golf club. Like these, it is a prolongation of the hand, a tool with which we hit the hammers against the strings, "to create speed in them," and so, in learning how to rest on the keys, we have learnt how to *take hold of our tool*. We must learn to move the key; and here, at the outset, it is evident that we must never *hit* our tool, but must rather take hold of it, and hit *with* it. "We must never aim *at* the key, but always *with* it."

And now, before learning to move the key, let us recall our first maxim.

Two-fold Use of the Key. The key has a two-fold function, therefore we have two separate and distinct things to do with it. We must (1) move it swiftly downwards to produce tone (hammer function). As soon as we hear the beginning of the sound the key's hammer-work is done. Then, if we wish (2) to prolong the tone, we must continue to lean gently (rest) on our depressed end of key, that its other end may continue to press up the stem of the damper, and so keep its felt-lined wooden head ½ in. distant from the strings. It takes very little to hold the damper up, so for this purpose a very light resting on our end of key suffices

Since the key has two functions, and it is best to learn one thing at a time, we shall try first with the finger how best to fulfil the hammer function of the key by *key-movement*. And let us, before trying with muscular activity and limb weight to move such a small thing as a piano key, try first an experiment on a larger scale with, say, an open door. The open door is the key, as at 2; our action in closing it is analogous to moving a key down. We have shut a door ever since our toddling childhood, and learned to do it, therefore, in the days when we were keen experimenters. We found it was of no use to shut it sharply, but instead, leaning gently against it with the hand or body, in order to judge its inertia or power of resistance, we gently and *persuasively* moved it forward. Now let us try to think that all the keys are little doors which we are shutting, and, with the hand resting on the keys, supported by the fingers, let the middle finger, say, push its key away, and the moment we hear the sound let the key rebound. Try this repeatedly with one or other of the fingers. If we have used the finger in the easiest and most effective fashion against the key, we shall feel as though the impulse within the finger were an *upward* one—upward by reaction from the key and finger-tip to its hand-knuckle. "Action and reaction are equal and opposite"; therefore, what the finger-tip does to the key, its knuckle-end does equally, in the opposite direction, to the hand.

Recapitulation. Let us try this again—the hand hanging limp from arm, resting on finger-tips. The finger gently supporting this loose weight rests on the key, and feels resistance of the key as we should feel resistance of the door we wish to move; then, pushing the key as we should push a door, set a see-saw in motion or move forward a swing with someone sitting in it, the feeling caused by this exertion of the finger will react upwards against the hand. We must *cease* this exertion the moment we hear the "*beginning* of the sound." The key will come up, the damper will go down, and the tone will cease. When we hear the tone thus suddenly cease, *we must not lift the hand off the keys*, although the key is now up, but let the hand still rest on the fingers, and each finger on its tool (key), ready to move one or another at will. Tones produced thus will all be short-lived, staccato and detached [8].



8. THE DAMPER

A. Ivory key-end depressed b. Damper on string
B. Damper off string c. String
a. Ivory key up

Sustained Tones. To produce sustained tones we must avail ourselves of the key's second function, its damper control. To keep a key down is as easy as to move it down at its softest.

Many pianoforte students, ignorant of the dual nature of the key's function, continue to use as much force against the key to keep it down as they used to move it down for a *forte*. To sustain a tone, however loud, we need do no more than lightly rest on the depressed key. The fingers must learn to keep the key down at their easiest. Try how gently we need rest on the keys to keep them down. It is the same kind of resting we did when the key was up, but *slightly* heavier.

Resting. We have learnt now the two kinds of "resting"—the resting that is not heavy enough to move the keys, and the resting that is just heavy enough to keep them down. These "restings," although they occupy so much of the time of the performance in a slow movement, are of the nature of waiting—waiting for the vivid movements of tone production—and are always the same, or vary very slightly. But the other thing we have to do to the key—the moving of it—must vary with every desired variation of tone. And the possible variations in this key-movement we shall now deal with. Tones may vary in (*a*) pitch, (*b*) quality, and in (*c*) quantity. For the pianist, the pitch of each note is fixed, but on his manner of using the key depends entirely the loudness and quality of the tone, and these can be affected by him only during the key-*movement*.

Tone-quantity. The pianist does not, like violinist or singer, *make* tone continuously—he makes tone in spurts and the instrument does the rest. As everything depends on these little spurts of exertion or impetus added to the resting, they must be accurately aimed. The key may continue its movement a little beyond the beginning of the sound, but must never be aimed past it. The key must be *aimed* to hit the sound, not to hit the little "buffer" pad beyond it. "The greater the speed of the movement of key, hammer, and string, the greater the tone-quantity produced by them"; so if we want a loud tone we must get up speed in the key-movement. If we want pianissimo (the very softest tone), the key must move as slowly as compatible with the production of sound.

Touch Formation. *Pianissimo* can only be obtained by the use of "weight touch," and is got by moving the key with the same slightly lapsed weight of the whole arm which provides the "resting" at bottom of keys for *tenuto* and *legato*. Try weighing down a common chord—say, C E G—thus. And now realise that, in doing this, we use a triple "muscular combination"—*i.e.*, finger exertion, hand exertion, and arm weight. All these three touch components may (1) be thus used together; or (2) we may eliminate arm weight and use only finger and hand; or (3) we may use finger exertion only "with loosely lying hand and self-supported arm." This last Mr. Matthay has christened first species of touch formation; the second (finger and hand) he has termed second species; and the other (finger and hand exertion and arm weight combined) he calls third species. Upon a thorough understanding and a proper application of these *three distinct species of touch formation* greatly depends success in pianoforte playing.

Now, "*ppp*" is evidently third species, for in it the key is moved down by the lapsed weight of the arm levered on to the keys by the exertion of the fingers and hand. Weight and exertion alike are in this case very slight. In producing tone thus, we have produced it at its very softest. At the same time the biggest tone obtainable from the instrument is got by the same triple combination—*viz.*, (1) arm weight levered on to the keys; (2) finger; and (3) hand exertion; but in this case the exertion and the weight are alike proportionately greater.

When we use only finger exertion with hand weight (first species) we can get great agility with little tone. When we use finger with hand exertion behind it, and hold away the weight of the arm (second species), we get less speed and more tone; when we use finger and hand exertion and more arm weight than for "*pp*," we get large tone, but still less speed.

Thus, roughly, we have dealt with tone-quantity and speed across the keyboard.

Tone-quality. The way in which key movement *is started* greatly affects the tone-quality. Thus a suddenly started movement gives us a hard, brilliant, clean-cut sound, whilst a more gradually started movement yields a full sympathetic tone. To be artists we want mastery of both qualities, and of all gradations of them. This mastery depends largely on our capacity for easy muscular discrimination. We must learn to use the different parts of our pianoforte limbs independently, or combine their actions and inactions at will. It may help us here to think of our fingers as little legs, and to imagine these miniature limbs running, walking, stepping up stairs, or running down hill, while the loosely lying hand is the body which they must always carry. The loose weight of the arm, on the other hand, is a burden which they may carry or not at will, a burden that may be thrown off when the little legs want to run very fast or very lightly—*i.e.*, *prestissimo* or *leggierissimo*. Now we must learn the trick of burdening and unburdening these little legs and bodies, letting in or lifting away the weight of the arm. As we learnt alternately to support and relax the hand, we must now learn to do so to the whole arm.

Arm Control Exercises. (1) Hanging limply from the shoulder, let the arm be tossed about by an external agency (our own free arm or that of a second person); let it remain perfectly passive, therefore limp.

(2) Now, resting the fore-arm horizontally on another arm, learn to distinguish these three possible different conditions: (*a*) actively pressing the arm down on another (using the down muscles of the arm), a condition never to be employed in our present stage in pianoforte playing, and later only very slightly at times—it would crush and lame and impede the movements of the nimble little runners; (*b*) merely letting our arm be in contact with the other, without really resting on it at all (using the up muscles of the arm)—this would lift the

burden completely off the little body and legs ; and (c) resting the whole limp weight of our arm on the other (completely relaxing all the muscles of the arm), a very necessary condition at times, and one that must be induced, during key-movement, for really big tones of any kind.

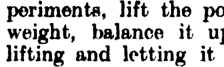
Let us work at this till we perfectly realise the three sensations : (a) Pressing down, almost invariably bad ; (b) merely touching without real resting—necessary for agility passages ; (c) letting the loose weight of the arm rest —this to provide the little spurts in big tone key-movement (called third species of Touch formation). Let us experiment with other people. Children usually master these willed variations in muscular condition much more quickly than adults. Do not let us confuse the required passive heaviness of relaxed resting with the undesirable active down pressure of the muscles of the arm, nor the stiffly rigidly held arm with correct gentle support.

The arm has four portions, and in the action and interaction of these different portions what the finger is to the hand the hand is to the forearm, and what the hand is to the forearm the forearm is to the upper arm, and so also the upper arm to the shoulder. It is always a case of one joint further removed from finger-tips. And, having recognised the general sensation of muscular conditions—*i.e.*, muscular *action* (limb supporting itself), and muscular *inaction* (limb hanging limp)—we must learn to locate and practise these in the separate portions of the arm. In such experiments, lift the portion gently ; to feel its weight, balance it up and down, alternately lifting and letting it fall ; then, finally, relax the upholding muscles entirely and drop it.

General Principles of Relaxation Exercises. Remember the general principles of all such exercises : (a) *Gentle* contractions for lifting or supporting a limb or part of a limb ; (b) absolutely loose, uncontrolled relaxations, allowing it suddenly to fall again at a definite moment of time. Such practice is more mental in its aim than physical—*i.e.*, it is not so much for the sake of strengthening and making flexible the *muscles*, as of training the *mind* to recognise and easily recall the sensations accompanying divers muscular conditions, and to make the limbs obey the will.

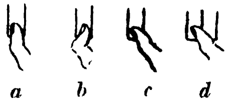
Technics at the Piano. Now let us return to the keyboard and apply this, taking any simple finger exercises. Such materials (technics) should always be memorised.

A time-honoured form, to be found in most collections, is this : Take the long notes here as representing a resting on the *top* of the normally undepressed key ; do not depress them to their low level. With the moving finger do not try to push the key too far down, endeavour to work only "to the sound" ; remember that the hammer reaches and propels the string just before we reach the key-bed felts. Experiment with different degrees of relaxed weight behind the fingers, and always see to it that the fingers' *work* feels *upwards* by reaction from the key. In using much weight behind the fingers, practise at first invariably staccato, and so let the weight be *unconsciously* caught up again by the upholding muscles of the arm.



If, when first practising with much weight, we play tenuto or legato, we shall risk letting the big weight of the loose arm *continue* to be a burden on the fingers, and this it must *never* do, as it would result in key-bed squeezing, and ruin our agility and powers of expression.

Equalising the Fingers. We must now try to equalise the fingers in the exercises; we must get the same quantity and quality of tone from each finger. The thumb is very apt to force down ; try to get with it also the sensation of playing "up" towards the hand. Its best *position* is that with the nail-joint in line with the key, thus (*a*), not obliquely across it, thus (*b*), or (*c*). Of course, when two adjacent notes are to be sounded together by the thumb, its nail-joint must then lie obliquely to the two keys (*d*). The whole thumb in the normal position should be held well away from the hand. We shall probably find that the fourth and fifth fingers of the hand seem to be the weakest, and we shall want to know how to strengthen them, how to make them "equal" with the other fingers.



Rotary Adjustments. In the forearm we have two long bones which can roll over each other, enabling us to rotate the forearm and with it the hand. We can thus turn the hand either palm upwards or palm downwards, or merely tilt it from side to side—a *rotary* motion of hand and fore-arm, a movement of the wrist round its centre, like that of a wheel round its axle. But we have seen already in the case of motionlessly upbearing fingers and loose lying hand that there can be muscular action and inaction without any visible *movement*.

The muscular habits of this forearm rotary control form no exception to the rule. We may visibly rock the hand to and fro, thumb side to fifth finger side, and vice versâ, with a rotary movement (as we do for certain tremolo effects), slightly rolling the fore-arm.

But, when we wish it, we can summon these rotary muscles to our service *invisibly*. We can relax the muscles that hold up the hand at one side or the other "rotarily," and the hand can then be made to tend to fall to either at will. In this way, weak fingers, making use of the weight which is tending to fall, will bear up against it, and at the same moment bear equally against the key, and, moving it swiftly down, produce a good tone. We can also make use of rotary *exertion*. At the weak finger side of the hand, then, use "rotary adjustment," remembering *only in proportion as we bear up with the finger against this rotary tendency to fall do we bring the weight to bear effectively on the keys.*

Continued

THE SKIN AND ITS USES

Growth of the Hair and Nails. The False and True Skins. The Sense of Touch. Common Sensations and their Protection of the Body. The Pores

Group 25

PHYSIOLOGY

10

Continued from page 1303

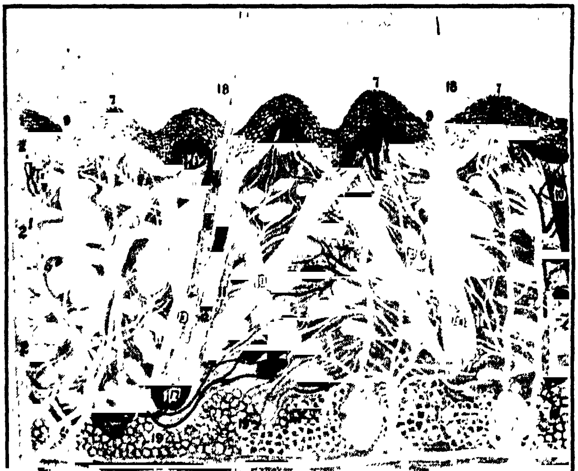
By Dr. A. T. SCHOFIELD

WE have now to describe the structure and the function of the skin ; the care of it will be dealt with in the section on health.

The skin [67] consists of two layers, the inner one called the *dermis* or *cutis vera*, which contains all the nerves of touch and feeling and all the blood-vessels ; and the outer one, the *epidermis*, or false skin, so called because it is over the true skin. It is thin, and contains no nerves or blood, so that when you prick it lightly, as in the finger when sewing with a needle, there is no pain and no blood.

The Hair and the Nails. The hair and nails are really hardened parts of this outer layer of the skin. Perhaps a short description of these will show how wonderfully even the epidermis is made. Being only the outer skin, one would think that it could not contain anything very interesting. We will therefore begin with the *hair* and the *nails*, the structure of which is remarkable.

How Hair Grows. Each hair sprouts, like a hyacinth or tulip, from a bulb deeply planted in the true skin, from which it continually keeps growing, while at the same time it dies away at the extremity. The surface of the hair is, as it were, thatched with cells overlaying each other like tiles, while the centre is not hollow, but filled with a sort of pith. Straight hairs are round, while wavy and curly hair is oval ; black is the coarsest, and flaxen the finest. Hairs do not grow straight out of the skin, but at an angle, so that they can be made to lie down flat. In the head they generally all radiate from one centre, and number about 100,000. It is calculated that four sound hairs will support a pound weight. The whole body is covered with them, though they vary greatly in length and quality. Those of animals serve, of course, for the purposes of clothing ; in man, they are principally an ornament.



67. VERTICAL SECTION OF THE HUMAN SKIN

(Greatly magnified)

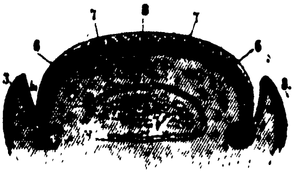
1. Epidermis. 2. Corium, or true skin. 3. Papillæ, showing blood vessels (vascular papillæ). 4. Papillæ, showing nerve endings (tactile papillæ). 5. Nerve fibres. 6. Sweat glands. 7. Openings of excretory ducts of sebaceous glands. 10. Muscles of hair follicles. 11. Hair follicles. 12. Outer root sheath. 13. Inner root sheath. 14. Fibrous substance of hair. 15. Medulla of hair. 16. Hair bulb. 17. Papillæ of hair bulb. 18. Shaft of hair. 19. Adipose tissue. 20. Artery. 21. Vein

Each hair grows out of a deep pit in the skin, that descends right through both false and true skins into the underlying layer of fat. This pit is lined throughout with the cells of the epidermis, or false skin, just as if the pit had been made by pushing in the skin. These tile-like cells that line the sides of the hair-pit point downwards, while the tile-like cells covering the hair point upwards, the one thus locking into the other, and preventing the hair from being easily pulled out. When, however, it is drawn out, it generally brings away the sides of the growing pit with it.

The Hair Bulb. At the base of this pit is a small pimple or bulb, made of the same epidermal cells. Just as the outer layers of this are about to die, they form a horny substance, as we shall see they do in the skin, but of a very superior nature. The outermost dead layer of cells instead of lying about anyhow ready to be brushed off, as it does on the skin, has the cells arranged, as we have seen, like tiles. The growth from below is fairly rapid, and, as no cells fall off above, the young hair is soon pushed up out of the pit, which it exactly fills, and goes on increasing in length until the growing bulb at the base is exhausted, when it finally falls off. Just as the hair leaves the skin a tube opens on each side of the "root" or hair pit, up which is discharged a natural pomade for the hair. Attached, too, to the bulb on the under side of the hair, and passing upwards to the skin, is a small band of muscle, which, by contraction, has the power of erecting the hair, so that it stands up or bristles when the person is agitated, as with fear, etc.

Frequently small bubbles of air get imprisoned in the hair, as they do sometimes under the nail, forming silvery or white patches. They make the hair silvery in appearance, which is quite different from grey hair. The latter is due to the pigment being all gone out of the hair with age, the former to the refraction of light in the air-bubbles in the hair.

The Nails. The nails [68] are beautifully modified outgrowths of the horny substance of the skin, and are of great use in giving firmness to the finger-tips and in grasping small objects. They grow in a peculiar manner, for at the base of a nail the outer skin is folded inwards into a deep trench, from the bottom of which these horny cells of the epidermis grow up in the same way as in a hair; this time, however, in the flat shape of the trench, instead of the round shape of the hair-pit. They are free from all pigment.



68. TRANSVERSE SECTION OF A TERMINAL PHALANX

1. Bone. 2. Nail bed (fibrous stroma and blood-vessels). 3. Nail wall. 4. Nail groove. 5. Papillæ of nail bed. 6. Malpighian layer. 7. Derma. 8. Horny layer.

The true skin which forms the bed of the nail is in ridges and furrows like a ploughed field, and the horny nail as it is pushed up from below often shows corresponding ridges [69].

The Skin. The false skin itself merits a short special description, if only to show the true interest and romance that pervade the story of the simplest and least complex of the body structures.

In the first place, the epidermis, like the rest of the body, is alive—that is, all but the outside of it.

In the next it is composed of from a dozen to twenty or more layers of living cells, packed side by side and layer on layer, just like the bricks in a wall. Each of these cells—like every other cell in the body—not only is born, grows, matures, ages, and dies, but eats, drinks, breathes, frequently moves, and certainly works, not only doing its share in supporting the general structure, but aiding in some special way besides.

History of a Skin Cell. The life history of one of these cells is interesting [70]. Born by the parent cell squeezing off part of its own body, it begins an independent life, the young cell forming one of a row of similar ones in the deepest layer of this outer skin, and next to the true one. Here the young cells are placed by the side of a small blood-vessel, which supplies them regularly with fresh air and their share of food. The cells are very busy carrying on a most important work, for to them is entrusted the manufacture of pigments from certain materials they take out of the blood stream and store up in their own bodies; they thus produce the colour of the skin. Of course, if the person be fair and the skin nearly colourless, they are not hard worked, though, when there is much heat or the sun is shining on the skin, they get very active, and produce the clear brown known as *tanning*, so commonly seen at the seaside; at other times, for some reason or other, they arrange the extra colour in little circles called *freckles*. But where the skin is dark brown or copper, or yellow or black, their work is, of course, immensely increased. After a time they become parents themselves by squeezing off part of their own bodies in their turn, and these new cells now lie next the blood-vessel, their parents having to mount a row higher and nearer the surface.

We have spoken of the bodies. It must be understood that each of these cells is composed of an irregularly shaped jelly-like mass, and is far smaller than the smallest speck that can be seen with the naked eye. The parents have now to depend for all their nourishment on their offspring next the blood-stream, who pass on what they can spare. Soon the parents become grandparents, then great grandparents, and being further removed from the blood-vessel—their only source of food—they get less and less of it, and as a natural consequence become smaller and smaller. Just before they die of starvation, however, the layer of cells next the surface sets to work once more, and manufactures a peculiar horny substance called *keratin* or horn—partly, it is suspected, out of their own bodies. This gives firmness to the surface of the skin and to the outside of the hair; then, reaching the surface, the particles of keratin lie in countless thousands in fine dust, which can be shaken out in clouds at night from one's garments, and scraped or brushed off the skin. They are often seen on a baby's cheek, and similar cells form the bloom on the grape.

69. LONGITUDINAL SECTION OF A TERMINAL PHALANX

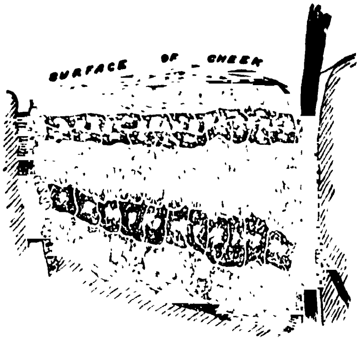
1. Bone of last phalanx. 2. Root of nail. 3. Nail. 4. Horny layer of skin

Such, then, in bold outlines is the story of one of the most insignificant structures of the body.

The True Skin. Coming now to the *Cutis Vera*, the derma or true skin, we observe that it differs in every way from the epidermis. It is arranged in ridges and furrows in many places, the folds of which the epidermis follows. The ridges are covered by double rows of papillæ, which are small projections connected with the organ of touch. There are also everywhere sensory nerves connected with the ordinary sensations and pain, small tubes connected with the openings on the surface called pores, innumerable networks of capillaries and lymphatics, and little glands that oil the hair. There is also a quantity of elastic tissue which enables the true skin to stretch, and the whole of it lies on a layer of fat [71], varying from ½ in. to 3 in. in thickness.

We will consider these structures and their uses in the order in which we have named them.

The Organs of Touch. The first are the organs of the sense of touch. This sense is principally connected with those ridges where, in double rows, are the elevations called papillæ, or pimples [72], of which we have spoken. Over other parts of the skin the papillæ are more or less thinly scattered, but nowhere so regularly arranged as in the hand and foot; they are about one-hundredth of an inch long. Each papilla is a perfect network of blood-vessels, and most of them contain an oval body—sometimes like a small silk cocoon—consisting of nerve fibres closely wound round each other. There are also, in some cases, little bulbs on the nerve fibres like small oranges. Although they are organs of touch, yet these papillæ are never allowed to come in contact with the object touched. They are all covered over with the epidermis, or scarf-skin, which is only thinly spread over the papillæ, but is thicker between them; so that the papillæ are isolated by it, and it is easier to tell which one is touched. Unless the papillæ were covered with the epidermis, the sense of touch would be lost. All feeling of *touch* is in the skin, but in very different degrees in the various parts of the body; for instance, if the skin on the back is touched at the same time with the two legs of a pair of compasses two inches apart, only *one* touch is felt; whereas on the tongue or fingers, however little the points are separated, *two* touches are felt. If a small portion of the skin be scraped off, and the raw surface be touched, a feeling of pain is felt, but there is no sense of touch.



70. EPIDERMIS, OR OUTER LAYER OF SKIN ON CHEEK, SHOWING PORE AND HAIR

The total thickness is not more than that of tissue paper

The tips of the fingers and the tongue have the finest sense of touch, which, however, may be lost if the object touching them be very cold or very hot. This delicate faculty of touch is the sentry of the body, giving immediate warning of the character of the substance with which the body is brought into contact. Animals, and especially those which wander about at night, are endowed with a far more subtle sense of touch than human beings. Cats, tigers, and others of the feline race, are very sensitive in the stiff hairs or whiskers protruding from the face, by which they discern the character of any near object before it actually touches the skin or fur at all.

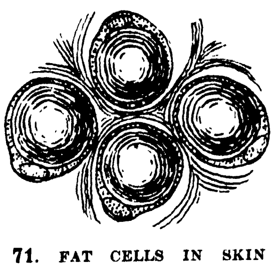
Sensation of Touch. We may now consider certain sensations of touch and pressure. The whiskers of cats, the antennæ or "feelers" of insects, the wings of bats, the trunks of elephants, the hands of man, are all instruments of touch. They acquaint their owners with the size, form, and other characteristics of bodies. Touching is as different from mere feeling as listening and looking are from mere hearing and seeing. This sense, however, often leads us astray if not corrected by other faculties, such as eyesight. The cavity in a tooth felt by the tongue is always imagined to be much larger than it is.

Curious illusions exist with regard to *touch*. If the eyes are closed and the first and middle fingers crossed, and a small pea or bead placed between them, two peas or beads are felt. This is caused by two parts of the fingers being enabled to touch the same small object, which they could not do unless they were crossed; so the mind wrongly concludes that there are two objects.

At first touch is not localised by the brain—only felt. An infant pricked by a pin only cries, but does not avoid the injury, because it does not know where it is. As it grows older a map, as it were, of the body is formed in the brain, enabling it to tell at once the point touched.

Sensation of Pressure. *Pressure* is a different sensation from mere touch. A card on the back of the hand touches it, but a leaden weight presses it.

The judgment of weight is based on the amount of pressure and of muscular effort needed to raise it. By lifting a weight it was found that a man could distinguish 19½ oz. from 20 oz.: while by the mere difference of pressure in laying the weight on the hand, he could only distinguish 14½ oz. from 15 oz. The combination of the two gives the most accurate results.



71. FAT CELLS IN SKIN FILLED WITH OIL, SHOWING THEIR SIGNET-RING SHAPE (*Greatly magnified*)

If a pin is pressed gently against the skin, the sense of touch is excited; or, still better, if it is held between the thumb and finger, the feeling it excites is at once referred to the pin. If, however, the finger is pricked with it, there is pain even after the pin is taken out—no longer connected with the pin, but with the finger.

A finger can discern blindfold whether it is touching silk, velvet, cotton, flannel, wood, iron, or stone; but if the outer skin be cut off, and the under skin left raw, only pain is felt when any object is touched, and their special sense is lost.

The accuracy of the sense of touch depends, as we have seen, on the nearness together and sensitiveness of the papillæ. The differences in various parts of the body are as follows. Two sensations are produced by the points of a compass at the following distances: Tip of tongue, 1-24th in. apart; tip of forefinger, 1-12th in. apart; nose, ¼ in. apart; palm of hand, ½ in. apart; back of hand, 1 in. apart; arm or leg, 1½ in. apart; back of neck, 2 in. apart; thigh, 2½ in. apart; and back, 3 in. apart.

Common Sensation. Under the head of common sensation are included the sense of temperature, pain, pleasure, itching, tickling, etc. This sensation does not depend upon the touch corpuscles merely, but upon the sensory nerves in the skin. This fact is important; for instance, the sense of touch does not depend on the thinness of the epidermis, but upon the number of touch corpuscles, and is hence most acute at the tips of the fingers. Sensation, on the other hand, depends directly on the thinness of the epidermis, and is most acute on the back of the hand, cheek, etc.

Common sensation is a great protection of the whole body, for just as the wall is the defence of a fortified town, and when that is passed the town is taken, so is the skin the vital fortification of the body, to which it is such a powerful defence that when it is gone to a great extent the life goes too.

The nerves under the skin are like the coastguards round our coasts, and give immediate warning to the central government when any enemy attacks the body.

The sensation of heat and cold is, again, quite different from that of mere touch, and depends on the thinness of the skin. This sensation is often very fallacious. If one hand be placed in cold water and the other in very hot water, and then both hands be placed in warm water, this will seem hot to one hand and cold to the other. In fever, again, we feel excessively cold when shivering, and yet are in a burning heat, while, when we perspire, we feel much hotter and yet are really cooler. People feel warmer after drinking spirits, and yet the temperature of the body is always lowered.

72. SECTION OF SKIN SHOWING (1) TOUCH PAPILLÆ
(*Greatly magnified*)

Use of Pain. Pain is a most valuable sensation, for it generally calls our attention to some injury or disease. It is difficult to tell where mere feeling passes into pain, but usually it is when any sensation becomes injurious to the body. Heat is enjoyable up to a certain point; then, as in the case of cold, it becomes pain, which can also be easily excited *by mere ideas of sensation in the mind. In fact, most sensations can be produced by ideas.* Tickling may be pleasurable or painful, according to its intensity, and can be produced with the greatest effect in the soles of the feet.

Itching can be produced by physical or mental causes, and may reach any degree of acuteness.

The Pores. Respiration and transpiration are other functions of the skin, and are carried on largely by means of the pores [73]. These are glandular structures connected with the skin, and concerning which the vaguest ideas are current. Some imagine them to be little holes in which the hairs are inserted; others, again, believe they are holes through the skin, opening into the body, through which the perspiration comes, the skin being thus a sort of sieve. Both these ideas are wrong. There are no holes in any part of the skin leading inside the body. The real "pore" is a tiny opening, guarded by lips, at the end of a short tube which has no opening internally at all, but is coiled up at the end like a watch-spring. These pores are really like little lungs which *breathe in* oxygen and thus keep the blood near the surface and the skin red; and *breathe out* about 400 grains of carbonic acid gas, besides about a pint of water a day. They are very numerous, and exist all over the body, though they are most numerous where most perspiration occurs, especially on the palms of the hands and the soles of the feet. It is of the utmost importance for health that the mouths of these glands or pores should be kept open and free from all obstruction, for in all there are no less than 28 miles of them.

By means of the pores, and also directly through its surface, the skin in this way does $\frac{1}{150}$ part of the work of the lungs as regards inspiration of oxygen, but about $\frac{1}{30}$ as regards expiration of CO_2. This can be shown as follows: If a hand be held in a closed lantern for two hours and then a candle be inserted, the latter will go out because of the amount of CO_2 in the air. The skin not only gives off CO_2, but other poisonous matters.

Hence it is that burns and scalds are more serious in proportion to their extent of surface than to their depth—it being less serious to lose a certain amount of flesh, and even of bone, than a large amount of skin. In injuries, too, especially about the hand and fingers, when they are maimed or crushed, the important point

that decides whether it is better to remove or to leave the injured parts is the amount of skin by which they remain attached, for on this the life of the part depends.

Amount of Water Given Off. But in addition to respiration, the pores excrete, as we have seen, a large amount of water. As a rule, this evaporates from the surface of the body all day long, and is called *transpiration*. When, however, the amount is so great that it cannot be carried off, but remains as drops on the surface, it is called *perspiration* or sweat, which has the following composition :

Water ..	99·5
Acids ..	·1
Salts ..	·1
Fats ..	·1
Other bodies	·2
	100·0

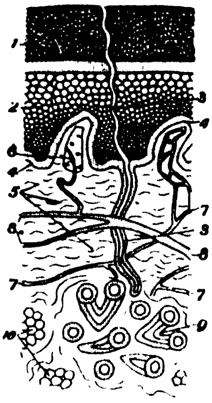
Two lb. of it is given off daily—twice as much fluid as comes from the lungs ; $\frac{1}{67}$ of the whole body weight is thus lost daily. The pores or sweat glands are most numerous and largest on the palms, the soles, the forehead, and the sides of the nose ; there are few on the back and neck, and none on the lips. In the palms there are 3,000 to the square inch ; on the neck 400. There are in all two and a half millions, and they present a surface of 3,000 square inches.

Perspiration is increased by heat, watery blood, exercise, drugs, nerve action and diseases, such as consumption and rheumatic fever. It is decreased by cold, excessive urine, rest, drugs, and nerves.

The sweat centre and that for dilating the skin blood-vessels generally act together, but there may be " cold sweat " with pallor and little blood.

Regulation of Heat. Owing to the innumerable blood capillaries just under the surface, the skin is also the heat regulator of the body, and acts like the balance of a watch, or the governor-balls of a steam-engine. When this power is lost the person dies, as in one or two cases where the skin has been varnished all over.

If the external air be cold, the skin contracts and tightly closes all the little blood-vessels, thus preserving the heat of the precious fluid by keeping it from the surface ; while, on the other hand, if the weather be hot, it allows the blood-vessels to expand, and by bringing the blood to the surface controls the heat of the body by the evaporation. This power is temporarily paralysed by certain drugs, notably by alcohol.



73. THE SKIN
(Greatly magnified)

1. Epidermis (horny layer).
2. Epidermis (deeper layer).
3. Sweat gland duct.
4. Papilla.
5. Subcutaneous tissue.
6. Touch corpuscle.
7. Blood-vessels. 8. Nerve.
9. Sweat gland. 10. Fat

Other Uses of Skin. Then, again, the skin is a secreting organ. It produces a peculiar oil for the hair, not only in the head, but all over the body. This oil is made under the skin in little vessels called sebaceous glands, which open by a small tube on each side of the tiny hairs with which the skin is covered.

But the skin has many additional uses. It is the beginning and the end of all the *beauty* of the body, which literally is but skin-deep. Whatever strength may be in muscle, there is no beauty in its bare appearance. Whatever loveliness exists in the rosy cheek, the white forehead, the well-rounded arm, or the graceful figure—all these vanish with the skin. A skinned rabbit has no beauty.

Continued

Continued from page 1250

OUTLINES OF EDUCATIONAL TOURS ABROAD

Itineraries of Holidays in Sweden. The Venice of the North. Denmark, the Homeland of Queen Alexandra. A Beautiful Archipelago

By J. A. HAMMERTON and WILLIAM DURBAN, B.A.

SWEDEN

Unlike Norway, Sweden contains very few mountains of any significant altitude, and there are no magnificent fjords on the immense coastline. But this great and important country of the Far North possesses charms of its own, which grow on the visitor. Its people are as interesting as any in Europe. The numerous large lakes form a very attractive feature, and the countless islands round the shores make a most romantic maritime environment. The lakes are reckoned to cover nearly an eighth of the whole area of Sweden. They yield enormous quantities of fine fish, so that Sweden is a paradise for the angling sportsman. The wonderful forests occupy almost a fourth of the entire land. Wolves, lynxes, foxes, martens, squirrels, eagles, reindeer, elk, deer of several species, lemmings, and feathered game in great variety abound. The country is full of attractions for the tourist of every category. Railroads are much more extensive than in Norway, so that travel is much more facilitated than in the sister country.

Suppose that a tourist is taking a rapid summer trip through the Scandinavian countries, wishing to enjoy glimpses of Norway, Sweden, and Denmark. It may be that he can only spare a week or ten days for Sweden. In this case he can gain an excellent idea of some of the peculiar characteristics of the country and the people by selecting the wonderfully interesting region between Gothenburg and Stockholm. He should, if he is entering by Norway, go by train from Christiania to Gothenburg, stopping for a few hours at the quaint old fortified Norwegian city of Frederikshald. At Gothenburg he will find much to see, and should stay for two full days. Then he will sail by the beautiful Göta Canal to Lake Wener. His next stopping-place by train journey will be Karlstad. Hence, he will proceed to Örebro, and after seeing this typical city in the heart of the country, he will make for the famous University city, Upsala. From Upsala a short journey brings him to the lovely "Venice of the North," and here at Stockholm the rest of the time available should be spent. The traveller will have had a delightful week or ten days, and he can take the night train for Malmö, in the far south of Sweden, and find himself in the morning looking across the Sound at Copenhagen.

A Fortnight in Sweden. In this time one may visit the most attractive points in the most accessible parts of the country. We will suppose that the traveller has reached STOCKHOLM, either from Germany by Baltic steamer from Stettin, a route which is favoured by some who wish to visit Germany first; or from Copenhagen by way of Malmö; or from Christiania after being in Norway; or by steamer direct from London; or by canal and train from Gothenburg.

FIRST DAY. STOCKHOLM. The famous and beautiful *Djurgaard*, the great park of which the people are so proud. The *Skansen Gardens*, on one of the most beautiful islands. Here, in the pleasure grounds, the national dances are performed by peasant girls in the costumes of the various provinces. A most interesting Lapp camp, with magnificent reindeer, is often exhibited here.

SECOND DAY. Spend some time in the old nucleus-district of Stockholm, especially the *Helgeaandholmen*, the *Stadens*, and the *Riddarholmen*. In this quaint and beautiful section are some of the finest private and public buildings. The *Royal Palace*, with its commanding view of the city, the islands, and the lovely lake, is rich in its collections of antiquities, paintings, and coins, and the gardens are very fine. Take the splendid walk along the various quays, and on the chief quay note the colossal statue of Gustavus III. Make one or two little trips on the steam launches which go constantly to and fro between the picturesque nine islands.

THIRD DAY. Still in Stockholm. Visit the *Riddarholms Kyrke*, where the kings are crowned, and make a special trip to *Sodermalm*, the finest of the nine islets, with its quaint old houses on terraces.

FOURTH DAY. Proceed to MAELAR LAKE, the gem of Sweden. It is 85 miles long, with an average breadth of 12 miles, and on its banks are many lovely little towns, several palaces, and hundreds of villas and summer residences.

FIFTH DAY. Next go on to UPSALA, with its grand old *Cathedral*. Here are the tombs of several kings, including Gustavus Vasa, and also that of Linnæus, the great founder of the science of botany. The ancient *University*, Sweden's chief seat of learning, with 1,400 students, is at Upsala.

SIXTH DAY. Visit OLD UPSALA, which was the seat of the worship of Odin. Make an excursion to the *Mora Stones*, which are four miles from Upsala, and were formerly used for the coronation of the kings.

SEVENTH DAY. Spend this at FALUN, the capital of the province of Kopparberg, or "Coppermine" Province. Falun is also called Gamla Kopparberget, or "The Old Coppermine." The excavations extend for miles underground, and in them are immense chambers where King Bernadotte gave banquets.

EIGHTH DAY. The traveller will now reach KARLSTAD, on the island of Tingvalla, in the beautiful Lake Wener. The *Cathedral*, the two fine *bridges*, and the *Town Hall* are the chief ornaments of the interesting old town. The walks in various directions about the margin of Sweden's largest lake are charming.

NINTH DAY. An excursion to TROLLHÄTTAN, where we may see the grandest waterfalls in Europe. Not far away are the famous factories where paper is made from wood-pulp.

TENTH DAY. Should be spent at JÖNKÖPING; beautifully situated on the southern end of Lake Wetter. There are celebrated match factories here, and lovely views from the hills at the back of the town.

Eleventh Day. At Wenersborg. Here the tourist is again on Lake Wener, and at this pretty town he takes passage down the wonderful Göta Canal.

Twelfth Day. On the Göta Canal; a glorious trip by steamer. The canal is the most wonderful engineering work of the kind in the world. The steamer has to pass 74 locks.

Thirteenth Day. The passage of the canal requires two days, but as the scenery is everywhere enchanting no one will consider the time ill-spent.

Fourteenth Day. Arrived at Gothenburg, we are in Sweden's busiest commercial city. The boulevards by the great ship canals make beautiful walks, and the splendid *Harbour* and *Cathedral* are among the chief objects of interest in the town. The Gothenburg system of licensing affords temperance workers and economists interesting study on the spot.

Longer Tours. *Three weeks* will give the traveller time for making more intimate acquaintance with Stockholm and Gothenburg, as well as for a short stay at such interesting places as Örebro, Jönköping, and Berg, which lie at points near the route just outlined. A *month* allows an extra week for the excursion up the Gulf of Bothnia to Tornea. Or the tourist may prefer to spend the time in trips to the romantic Aaland Isles and the island of Gottland, with its fascinating archæological associations.

Travel, Food, and Expenses. The Swedes are a charming people. They are universally well educated. The land overflows with abundance. The cooking, however, is peculiar, and differs greatly from that of both Norway and Denmark. At the railway stations are hot provisions of great variety always ready, in Russian style, so that the traveller during the intervals frequently allowed, can make a comfortable meal. It is a national custom to stand before dinner at a buffet covered with a bewildering variety of relishes, and to partake of these as appetisers. This preliminary is called the "smörgäs." On the steamers the service is excellent. Indeed, travelling in Sweden is luxurious. The popular standard of comfort is high. As in Norway and Denmark, the traveller cannot expect to spend less than about one pound each day when travelling in Sweden. The fare from London to Stockholm is: First Class single, £8 3s. 9d.; return, £12 13s. Second Class single, £5 19s. 4d.; return, £9 10s.

Books to Read. Books descriptive of Sweden are very numerous, and many of them are excellent. Specially to be commended are C. Wood's "Under Northern Skies"; Mrs. Baker's "Pictures of Swedish Life"; Howitt's "Twelve Months with F. Bremer"; Bayard Taylor's "Northern Travel"; Lady Westminster's "Sweden"; Von Heidenstam's "Swedish Life in Town and Country"; and "Ten Years in Sweden, by an Old Bushman."

DENMARK

"Dear little Denmark!" is the succinct description often uttered by those who have come to know the country so romantically situated between Northern and Central Europe, washed by stormy seas, cut off from the wild lands of the Farthest North only by the narrow Sound and the Skager Rak, and linked by the racial affinities of its delightful, quaint, and highly cultured people with both the Teutonic and the Scandinavian nations. Denmark, in its curious archipelago contains some of the beauty-spots of Northern Europe; and its mainland, the great Jutland Peninsula, is for its systematic, scientific, and wonderfully flourishing dairy-farming the most interesting section of the whole Continent. The Danes are but a little nation, but in certain practical directions they have beaten the world. And their country contains some of the most singular remains of the oldest of civilisations.

A Week in Denmark. So short a holiday would need to be spent mainly in and around Copenhagen, and a more delightful week could hardly be imagined. A traveller who had for years been going about the world, when asked which city he would prefer to live in, at once said, "Copenhagen, undoubtedly!" To all English hearts Denmark appeals as the native and beloved home of Queen Alexandra. And Britain has no sincerer friend than the stalwart little people who guard the gateway of the Baltic. Places round Copenhagen are replete with associations connected with the mutual histories of the two nations. The traveller who can spare a week only in Denmark should spend three days in surveying the sights of the capital itself, and the rest of his time in such delightful resorts as Fredensborg, Skodsborg, Rosenborg, and Elsinore.

A Fortnight in Denmark. This allows ample opportunity for seeing all the attractive places on the favourite tourist routes in the country.

First Day. On the first day in Copenhagen one might see the famous *Gammel Straede*, or Fish Market; the quaint *Vegetable Market*, with the fountain decorated with bronze storks and frogs; the celebrated *Vor Frue Kirke*, or Church of Our Lady—a perfect Thorwaldsen Museum of itself, as it was decorated entirely by the great sculptor—the gigantic white marble figure of Christ Risen standing at the chancel end, and the beautiful statues of the Twelve Apostles in the nave. The *Thorwaldsen Museum*, where are seen the originals, or casts, of all the great master's works, would wind up a full day of sightseeing.

Second Day. Visit the *Christianshavn Quarter*, where are the *Frederikskirke* and the splendid *National Museum*. The evening should be spent in the lovely Tivoli Garden and Concert Hall, the popular pleasure resort within Copenhagen.

Third Day. Excursion to *Amalienborg*, the beautifully situated palace of the Crown Prince. Visit the *Royal Picture Gallery*, containing many masterpieces of native art. The *Cathedral* and the *Church of the Trinity*, with the famous Round Tower, may be included in the day, as also *Rosenborg Castle*.

Fourth Day. Train to *Hilleröd*, for *Fredriksborg Castle*, a magnificent structure by the lake, now used as a historical museum.

Fifth Day. Excursion to the grand Royal Deer Forest of *Klampenborg*.

Sixth Day. Excursion to *Skodsborg*, the beautifully situated health resort on the Kattegat, with its magnificent beech forests behind the little town and fine sea view in front.

Seventh Day. Visit to the Royal Palace of *Fredensborg*. Here is the favourite residence of the

Royal Family in summer. It is a famous meeting-place of European Royalties. Glorious park, famous for its splendid pines and noble beeches. The *Esrom Lake* is a fine sheet of water.

Eighth Day. Devote to Elsinore, a beautiful, quaint, historic city, where the chief sight is *Kronborg*, known as "Hamlet's Castle," with the lovely pleasure grounds, known as "Hamlet's Gardens." The charmingly picturesque old castle, with its 365 spires, emblematic of the days of the year, was built by Frederick II. in the sixteenth century. Among the paintings is a portrait of Rubens' daughter, by the great master himself. There is also one of Hamlet the Dane, by Abildgaard. In the vaults below the castle, according to popular legend, rests the stalwart hero of Denmark, Holger Danske, wrapt in slumber, a well-known character in Hans Andersen's fairy tales, who will come forth when his country is in peril. The Flag Battery is the platform where Shakespeare makes the ghost of Hamlet appear. The reputed "Hamlet's Grave" is on an elevation behind the gardens of Marienlyst.

Ninth Day. At Roskilde, the ancient capital of Denmark, and the burial place of the Danish Royal Family for ten centuries, beginning with Sweyn, nephew of Canute.

Tenth Day. Visit *Schloss Bernstorff*, a lovely château, used frequently as a summer residence of the Royal Family. Near by is the quaint old village of *Gjentofte*. The walks in the neighbourhood are exceedingly beautiful. The traveller will by this time be fairly acquainted with the chief scenes on the island of Zealand, on the east coast of which the capital is situated. He can now spend a few days in surveying certain portions of Jutland, crossing the Great Belt, traversing the island of Odensee, then crossing the Little Belt. Or he may take steamer from Copenhagen to Aarhus.

Eleventh Day. Aarhus, an important spot on the middle section of the eastern side of Jutland. The grand old *Cathedral*, dating from the thirteenth century, has elaborate frescos on the interior walls, very old and quaint, and wonderful sepulchral mural monuments.

Twelfth Day. Silkeborg. Scenery here, in the interior of Jutland, is very lovely. A tiny steam launch runs along the lake twice a day to *Himmelbjerg*, the little landing-place for the only considerable hill in all Denmark, 515 ft. high. From the summit is a superb view of the chain of lakes.

Thirteenth Day. To Veile by train. Here is a long fjord. The tourist proceeds across the narrow base of Jutland to the west coast. Arrives at Ribe.

Fourteenth Day. Ribe. After visiting the old *Cathedral*, take train to Esbjerg, which is an altogether modern place, sprung into existence as the new port for steamers from the west. It has been created by the wonderful development of the butter, bacon, and egg export trade. Esbjerg is the Chicago of Denmark.

Longer Tours. *Three weeks* in Denmark would give the tourist facilities for further investigation of the other islands of the archipelago. The sisters to Zealand—Alster, Laaland, Langeland, and Fünen, are all worth visiting in turn. They contain many prosperous and picturesque little towns and villages. The system of small holdings and of co-operative dairy-farming may be studied with great profit. A *month* will allow of a trip to the northern regions of Jutland. Aalborg, on the Lym Fjord, is full of quaint fascination, and may well detain the visitor for two days. Trips to Fredrikshavn and Skagen are curious and memorable experiences amid unique scenery.

Travel and Expenses. Denmark may be reached most conveniently by steamer direct to Esbjerg, the port on the western side which has come into note specially during recent years; or by rail, after crossing the Channel, through Brussels, Cologne, and Hamburg to Kiel; but all who love an ocean voyage prefer to sail from Hull, Newcastle, or Leith to Copenhagen. Thus, the fine scenery between Denmark and Sweden is enjoyed in passing the Skager Rak, the Kattegat, and the Sound. It is a sail of 50 hours. But the voyage from Harwich to Esbjerg only takes 27 hours. The cost of travel in Denmark is very moderate. The almost uniform flatness of the country renders it a perfect paradise for the cyclist as also for the pedestrian. A visit to Denmark is peculiarly charming on account of the constant variety of locomotion, now by train, now by steamer. Expenses are less than in Norway and Sweden, for food is remarkably cheap. Bread and cakes, the latter of endless variety, are everywhere delicious. Milk and butter are of the finest quality. The Danes love sago and ground-rice puddings with curious mixtures of gooseberry pickle, raisins, sultanas, and bilberries. The "smörgäs," or sideboard appetiser before meals, includes a bewildering variety of sandwiches.

The fare from London to Copenhagen by cheapest route (General Steam Navigation Company's steamer from Harwich to Hamburg, and thence viâ Kiel and Korsor), is: First Class, £2 16s. 8d.; Return, £4 12s. 6d. Second Class, £2 8s. 11d.; Return, £3 19s. 8d.

Language and Literature. The language of the Danes is identical with that of the Norwegians, but is different from that spoken in Sweden, though cognate. Dano-Norwegian is easily learnt sufficiently to enable the tourist to make himself understood. The British are exceedingly popular in Denmark, so that the country is one of the pleasantest for a Briton to travel in. The literature of travel in Denmark is of special interest. Very instructive are Otte's "Denmark and Iceland"; Marryatt's "Residence in Jutland"; Edwardes' "In Jutland with a Cycle"; and Laing's "Denmark and Duchies."

Continued

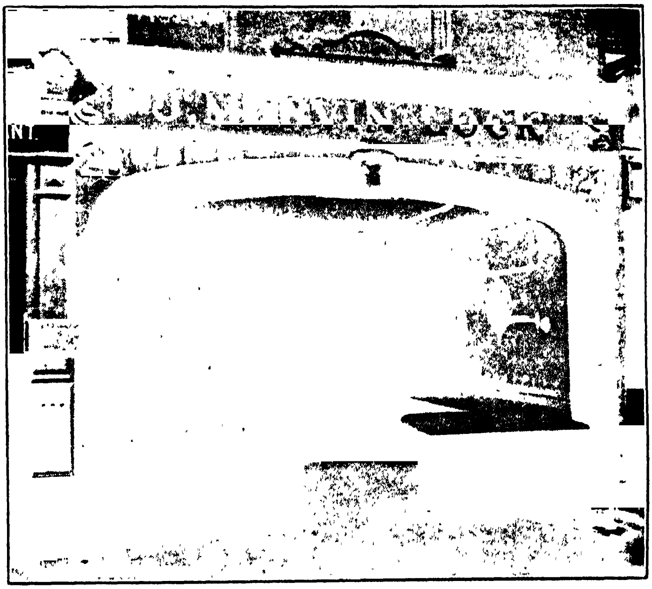
CYCLOPÆDIA OF SHOPKEEPING

Continued from page 1332

BUTCHERS. Locality and Premises. Fittings and Tools. Cutting up Meat. Prices and Profits. Pork Butchers. Recipes

BUTCHERS

We assume that the young man who thinks of becoming a master butcher has had a thorough practical training in the business. Books cannot teach him this—only service in all departments with competent masters will give him a grasp of it. But after learning all he can from his employers he has a good deal still to learn, and some of this knowledge he may profitably acquire from books. We assume also that the young man is prepared to do all that is necessary to make success certain—even to sleeping under the counter should the drawings at first not provide enough for both a house and a shop. In every new venture where the means are moderate there comes a time of stress. Credit must unfortunately be given, and just when things are really doing well, and orders are coming in faster, the pinch will be felt. Most of the capital will be lying in the hands of the customers, a good deal going out, but very little coming in, and how to make ends meet will often be a sore problem. The young man who is going to succeed will have prepared for this by keeping his personal expenses down to the lowest possible figure, and by purchasing, even for business purposes, only such things as cannot be done without. No smart horse and trap for him until he can afford it. Experienced accountants state that three-fourths of the businesses which come into the bankruptcy court owe their failure to the personal extravagance of the partners.



1. A MODEL BUTCHER'S SHOP

Choice of Locality. Whether a start should be made in town or country will depend on previous training. In town the butcher generally purchases his meat, cut up in sections to suit his trade, from the wholesale markets. In the country he buys "on the hoof," and kills for himself. In the town market he can buy exactly what suits him; in the country he must dispose of the whole carcase and the offal as well.

Very often, to obtain a suitable site, the new starter must either buy a business already made or open a new shop in a rising neighbourhood. One advantage in buying a ready-made business is that he can get to know pretty well what the probable turnover is. On the other hand, he may pay too much for the business, or may not have enough capital for its purchase. The plan of opening a new shop in a rising locality is perhaps more speculative, but on the whole it offers to the beginner the most likely avenue of success. A shop in such a locality, with house room over it, can usually be had at a moderate rent. The business may not be large to begin with, but it will probably be large enough for the capital available. It will grow steadily; and if a shrewd bargain has been made as to rent and option of long lease, and the right site has been chosen, it will probably become one of great value in a few years. We have known men who have developed several such businesses, and then sold them at very good profit.

Everything depends on the site; and the rule for choosing this is very simple. Have your shop in the position where the greatest number of possible buyers are bound to see you. It may be fatal to be even a very short distance out of the main current. We know streets in London where the butchers' shops on the "off" side of the street are always changing hands.

Ornamentation. One of the best advertisements a butcher can have is a well-appointed shop, and the question of decoration should have the most serious consideration. Undoubtedly the best and most sanitary covering for the walls is glazed encaustic tiles, *if the cost does not put them out of the question.* An average shop of, say, 12 ft. frontage and 15 ft. depth, may have a 3½ ft. dado of coloured tiles, with the space above, up to the ceiling, in white tiles with coloured panels, the stallboard finished with variegated tiles, door and lifting window in good style, and an ornamental signboard over all, delivered and fixed for about £100. Our illustration [1] shows such a shop. If the thin, vitreous tiles, now so commonly used, are adopted, the cost would be considerably less. Should even this be too expensive, the walls may be well painted with three coats of paint, the last one a coloured washable enamel, for a sum of from £15 to £20.

Outfit. Against the back wall should be placed a cash desk, with a door at the side and a lifting window in front, the cost of which in good pine, varnished, or in American white wood, stained and varnished, is about £8. A pound or two extra spent on having the stained white-wood desk polished greatly improves its appearance.

Along the side of the shop further from the door is placed a bench for pieces, costing £2 to £3. In front of this may be put a French block with stand and drawers, the price of which may be anything from £2 to £10, according to size.

The bar work on which the meat is suspended should be of bright steel, and a section of 1½ in. by ⅜ in. is quite strong enough. One hundred feet of this bar will furnish amply a shop of the above dimensions, and at the usual price of 1s. per ft. run, this amounts to £5. The hangers for suspending the bars to the walls or ceiling are more expensive, especially if polished, the average prices being from 1d. to 2d. per lineal inch, black, and 2d. to 3d. polished. As the latter require a lot of labour to keep them bright, we recommend black hangers painted with enamel as being the most suitable. The cost of these for the shop would run up to £6 or £7. Rail hooks may be either polished or tinned. The latter are very cheap, and a very good assortment can be purchased for less than a sovereign.

A marble-topped wall-table may be added to the outfit if thought necessary, at a cost of £5 or £6, and a piece-board, on frame, costing, say, 30s. The weighing scale, with a capacity up to 28 lb., with brass bell weights, will cost £3 or £4, and a small table on which to stand the scales about 15s.

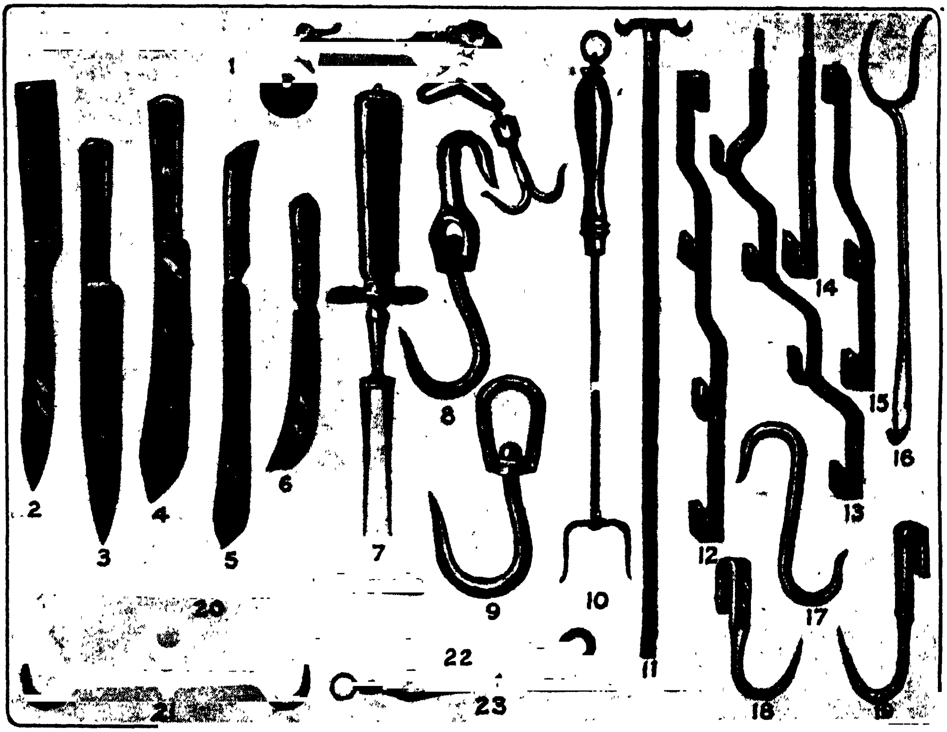
The following are the miscellaneous items of outfit, and will increase the expenditure by £13.

	s.	d.
A steelyard, or Salter spring balance, as may be preferred, to check the weight, rope and pulley with blocks and eyebolt to lift the scale with the meat attached .. .. (say)	80	0
Oak pickling tub, 55 gal. capacity ..	45	0
Assorted price tickets .. (say)	10	0
Three enamelled iron window-dishes	10	0
Two butcher's trays	10	0
Two salt meat trays	11	0
Salting pump (4 gal. capacity) ..	47	6
Assorted hickory skewers (4½ in. to 8 in.) .. .. (say)	10	0
Galvanised iron pail	1	6
Long arm, 6 ft.	2	0
Bow saw, 20 in.	5	0
Back saw, 18 in.	4	6
Smithfield chopper, 12 in.	4	3
Lamb chopper, 10 in.	3	6
Two butcher's knives, 10 in.	3	4
Steak knife, 10 in.	2	0
Dagger-pointed knife, 10 in.	1	8
Steel	5	0
Block scraper	1	6
Wire block-brush	1	3
Ordinary scrubbing-brush	1	0

Cold Chamber. Without the aid of refrigeration it is extremely difficult to conduct a butcher's business satisfactorily in the summer, or even in the moist muggy days we have so frequently towards the end of the year. The beginner will most probably not be in a position to expend, say, £200 on a mechanical refrigerating plant. Besides, it would be too large for his requirements ; but he can procure a first-class cold room—dimensions, say, 4 ft. 6 in. wide, 3 ft. 6 in. deep, and 7 ft. high—worked by ice, for £15, delivered and erected. The room should be insulated with good material—silicate cotton preferably—and lined with zinc sheeting. The ice crate should be made of galvanised iron rod, and the drip-tray underneath should be insulated to prevent the condensation of moisture on the under side, the ice water being taken outside the chamber by a trapped pipe. Separate doors for the ice and for the meat are the best arrangement. Automatic ventilators in the top are necessary, and wooden mats, in sections, to facilitate removal for cleaning, are the proper covering for the floor. This chamber will use from 2 to 2½ cwt. of ice per week, and the ice crate should always be kept as full as possible. Its capacity will be about two quarters of beef and four or five carcases of mutton, besides pieces. The larger items are hung from galvanised rails placed under the ceiling, and the smaller to wooden rails fastened near the sides. This chamber may stand in the shop, or in premises behind, or in a cellar. If possible, it should be placed where the sun does not shine on it. The great majority of butchers now have cold rooms ; but such a contrivance is an especially important fixture for the beginner, as his meat goes off slowly, and would soon lose its bloom and quality if he had not a chilled atmosphere in which to store it.

Cleanliness. Every purveyor of food should study cleanliness, but the butcher, dealing in a very perishable article, requires to devote particular attention to it. All woodwork should be washed daily with hot water, soap, soda, and the scrubbing-brush. The rails and tools must be kept clean and bright, and no dirt allowed to gather anywhere. Means of thorough ventilation of the shop when closed should also be provided.

Legal Obligations. Under the Acts which regulate the sale of food, the butcher who sells meat unfit for human consumption is liable to heavy penalties, and these penalties will no doubt become heavier as time goes on. It is easy to submit doubtful meat to the market inspectors, or to call in the medical officer of health in the country. If meat is found to be unsound in the shop or on the premises, it should be removed without a moment's delay, because if the inspector discovers it he will presume that it is being offered for sale. If the meat cannot be removed at once it should be *de-natured* by soaking it with, say, paraffin oil, which would prove conclusively to the inspector that it was not intended to be sold as food.



2. ITEMS IN THE BUTCHER'S OUTFIT

1. Steelyard. 2. Boning Knife. 3. Dagger-pointed Knife. 4. Butcher's Knife. 5. Steak Knife. 6. Block Scraper. 7. Cook's Fork. 8 and 9. Swivel Hooks. 10. Window Fork. 11. Long Arm. 12, 13, 14 and 15. Types of Hangers for carrying Meat Rails. 16. Copper Fork. 17, 18 and 19. S and Rail Hooks. 20. Ham Slicer. 21. Gambal. 22. Steel Skewer. 23. Steel.

The law as to the use of preservatives and colours on meat and in sausages is in a curiously indefinite state. The recommendations of the Departmental Committee appointed in 1899 have not yet been dealt with legislatively by Parliament, and no clear definition of the responsibilities of the purveyor of food in this connection can at present be given.

Buying and Selling. The country butcher has generally to buy his cattle and sheep alive, and only long practice will enable him to figure up the value of a beast as it stands. Generally, he cannot sell the whole of it, but must consign a portion to London or other large markets. The town or suburban butcher has many advantages. He requires to be at Smithfield bright and early, but he can buy exactly what he knows he can sell. If he cannot dispose of whole quarters or carcases he obtains pieces at a very trifling increase of price. Tripes, cheeks, hearts, plucks, and other offal he finds lying ready to his hand. His purchases are delivered early for the morning trade—although, of course, it is a great advantage to have his own van when he can afford it. It is the general practice in the London trade to canvass for orders, and this almost necessitates at least a lad as an assistant.

Cutting up Meat. *Beef.* At the slaughter-house the carcase is split down centrally through the backbone, or chine, into two equal halves, or sides of beef, and if the butcher buys his meat by the side he divides it further, as in 4 [page 1432]. He saws through the backbone at about the sixth joint, counting from the rump end, then enters his knife under the first rib, passes it along to the end of the rib, and then downwards to separate the thin flank from the brisket. The side is then divided into fore and hind quarters, of which the average weights are 44 stone and 46 stone respectively.

The further division into pieces is sufficiently indicated in the illustration, the general weights of the pieces being as follows:

1. Hock	14	to	18 lb.
2 and 3. Round and buttock	40	,,	48 ,,
4. Aitchbone	12	,,	14 ,,
5. Rump	30	,,	32 ,,
6. Thick flank	20	,,	24 ,,
7. Sirloin	36	,,	40 ,,
8. Six ribs	28	,,	30 ,,
9 and 14. Four ribs and leg of mutton piece	40	,,	45 ,,
10. Two ribs	40	,,	45 ,,
11. Thin flank	24	,,	26 ,,
12. Brisket	20	,,	22 ,,
13. Neck	40	,,	45 ,,
15. Shin	8	,,	12 ,,

Mutton. A good English sheep weighs when killed, cleaned, and cooled, about 70 lb. It is split down like a carcase of beef, therefore each side will weigh about 35 lb., and the side is cut up as shown [**5**, page 1433], as follows:

Leg	9 lb.	8 oz.
Loin	7 ,,	14 ,,
Neck	7 ,,	4 ,,
Shoulder	6 ,,	13 ,,
Breast	3 ,,	9 ,,
	35 lb.	0 oz.

In the above analysis of weights the neck and scrag-end of neck are included under the item "Neck."

Pork. The butcher's porker averages about 96 lb. in weight, and the side [**6**] therefore weighs, say, 48 lb., and cuts up into the following:

Leg	9 lb.
Loin	17 ,,
Spring	8 ,,
Hand	4 ,,
Spare rib	5 ,,
Head	5 ,,
	48 lb.

Sausage Making. In the cutting up of meat a good many small pieces and oddments are produced, which fetch low prices, and the thrifty butcher, therefore—in the cooler weather, at least—turns these into sausages. The outfit for this part of the business need not be expensive. Many thousands of tons of sausages have been made with the No. 32 hand-power "Enterprise" meat cutter, a machine that has had an extraordinary vogue among butchers in all civilised countries, and which may now be purchased from almost any dealer or hardware merchant at the low price of 15s. A more modern and improved machine is that shown on next page fixed to a table, and retailed at £2 2s. 6d. It is enamelled inside, and the meat propeller is made hollow, with the knife spindle passing through the centre, the latter being driven at about double the speed of the former.

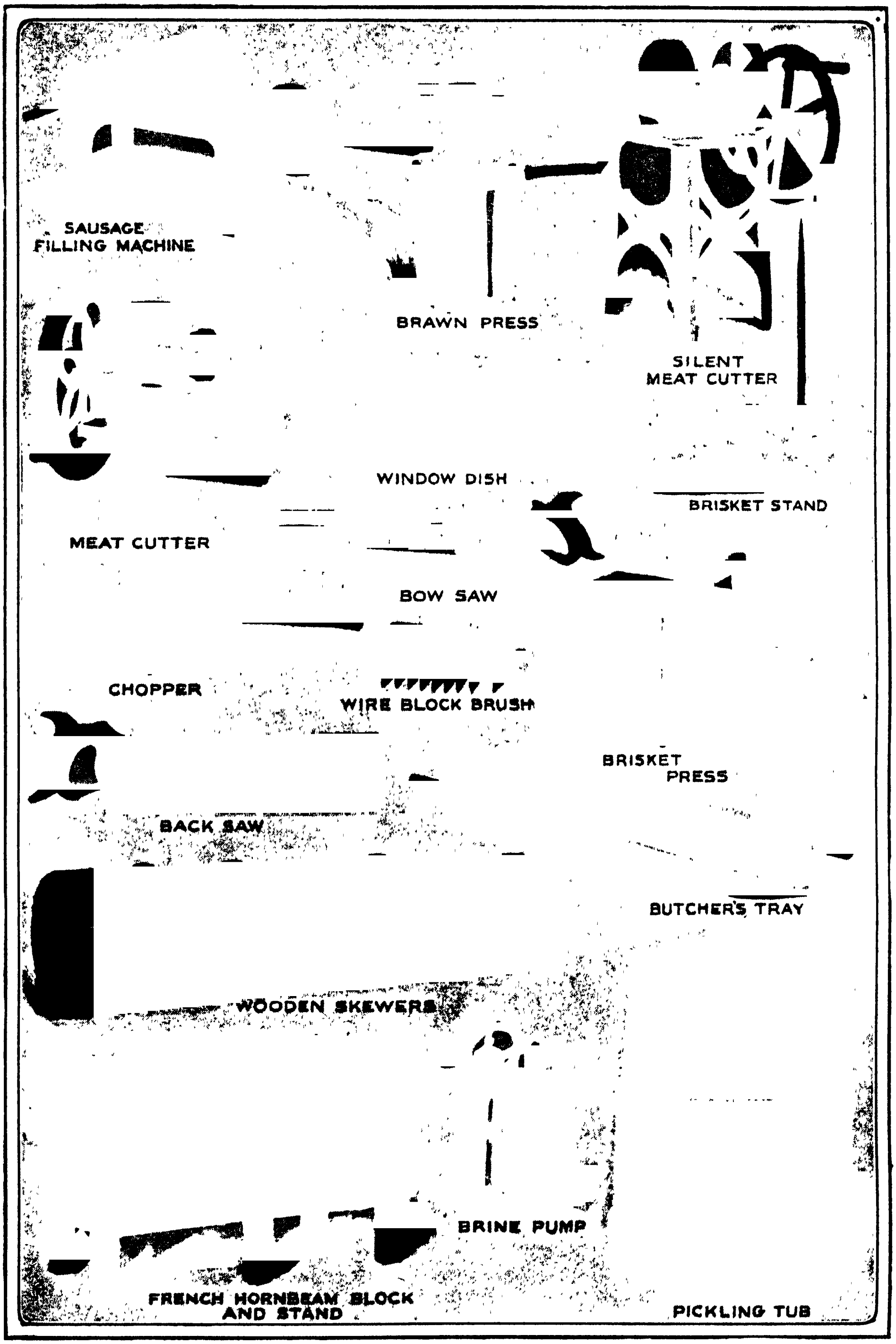
This arrangement avoids the crushing and bruising of the meat, which takes place in the "Enterprise" machine, owing to the propelling power being in excess of the cutting capacity of the knife. The newer machine has a series of graduated perforated plates, changeable at will, so that sausage meat, pie meat, or fine pastes, can be produced with equal facility, and either one or two knives with corresponding plates can be used; thus the machine is capable of great variation to suit different purposes. For filling the sausage meat into the *casings*, or skins, the barrel filling machine, with plunger, ratchet, and gear and nozzle, is used, and one of 12 lb. capacity may be bought for 30s. A bench or table on which to cut up the meat and mix it with the seasoning, a knife or two, and a pail in which to steep the casings, complete the outfit.

Casings and Contents. The casings are the cleaned small entrails of the pig or sheep. In England the former are used for beef sausages as a rule, and in Scotland the latter. These casings in the salted state can be bought from numerous dealers, the prices varying from 1s. 6d. to 2s. per lb., shaken free from salt. From time immemorial a certain proportion of bread has been mixed with sausages, and even the law courts have decided that, as the custom is old and universal, the sausage may now be taken as a mixture of meat and bread. This gives an opportunity to the unscrupulous; but, on the other hand, the public are very easily alarmed about sausages, and if the quality is inferior, the sale will be small. A sausage containing only good beef and seasoning is a very toothsome article, and we have known firms who have built up a good and profitable business by making a speciality of a pure sausage containing only the best material. It is very difficult, however, for the average butcher to fight against established custom—and what can be expected in sausage retailed very often at 4d. a pound?

The meat is weighed out and cut into pieces that will go easily into the cutting machine. The bread is soaked in water, and the surplus squeezed out in a press or wrung out in a cloth. The meat is spread out on the bench, and the bread placed equally over it; then the seasoning is scattered over the surface at the rate of ½ oz. per lb. of meat and soaked bread combined. A little of any of the harmless colours approved of by the Food Preservatives and Colourings Committee may be added, and the whole mixed together. The following is a good composition for the above-mentioned seasoning.

25 oz.	ground white pepper
50 ,,	salt
2 ,,	ground nutmeg
1 ,,	,, ginger
1 ,,	,, pimento
1 ,,	,, corianders

The whole should be rubbed through a sieve and well mixed. The spices should be of the best quality and thoroughly fresh. The sausage mixture is then passed once or twice through the cutting machine. In the meantime the casings have been soaked in lukewarm water to soften them, and a length of casing is slid on to the nozzle—quite 20 ft. may be got on without trouble. The chopped meat is thrown into the barrel of the filler, which is tilted up for the purpose. The barrel is then adjusted and the

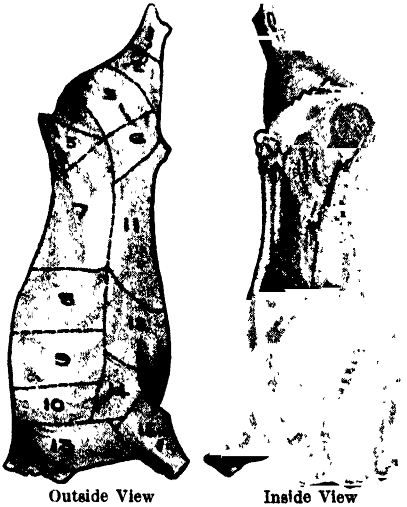


3. ITEMS IN THE BUTCHER'S OUTFIT

plunger run forward by turning the handle. When it reaches the meat the latter is squeezed through the nozzle, and carries the casing with it, the left hand of the operator keeping hold of it to regulate the rate. The long length of sausage is then weighed into pound quantities, and each pound is doubled up and divided into six links, which are twisted over and worked into a neat package, or the links may be hung loose on hooks in the shop window. When a large trade in sausages is done it is necessary to have a silent bowl meat-cutter, with a motor or gas-engine to drive it, a larger filler and bread-press; the outfit costing anything, according to size, from £50 upwards, delivered and fitted.

Prices and Profits. The retail prices vary very much according to the state of the markets and the locality. An expensive West End shop requires larger gross profits than one in a medium or poor locality. It would not be of much service to give fixed prices for goods which vary so much in value; but it may be taken that a fair average of gross profit, all over, on home-killed meat is about 15 per cent.—or, say, 3s. in the pound, or a little under 2d. in the shilling. In foreign meat, as the range of values is lower, while the turnover may be no greater, the percentage of gross profit should be higher to secure the same return.

If the beginner keeps his eyes open, he will soon, with the above facts before him, be able to work out his list of prices. He will compare the prices of cuts of beef in the wholesale markets with those at which his neighbours are selling them, and he will make a practice of weighing all his own cuts, and calculating what they will bring him in, less bone and fat, and in this way he will see exactly how he is going.



Outside View Inside View

4. SIDE OF BEEF, SHOWING CUTS

1. Hock. 2. Round. 3. Buttock. 4. Aitchbone 5. Rump. 6. Thick Flank. 7. Sirloin. 8. Six Ribs. 9. Four Ribs. 10. Two Ribs. 11. Thin Flank. 12. Brisket. 13. Neck. 14. Leg of Mutton Piece. 15. Shin

Pork Butchers. The business of a pork butcher is in many respects different from beef butchering. The beef butcher sells the greater part of his meat in its natural condition, while with the pork butcher sausages and made dishes form the bulk of the business. The London pork butcher is, in addition, a purveyor of hot cooked meats and vegetables. Very hard work is the rule in pork butchering, and the profits are frequently by no means excessive.

The general equipment of the shop does not differ greatly from that of the beef butcher. The walls should be tiled, and marble is generally used for the side tables and window. The bar work is modified to suit the smaller and shorter pieces handled, and it is a common practice to have one or two glass shelves in the window, hung with brass chains on which to display the more fancy goods.

Equipment. The equipment is as follows.

Salting Tanks. As the pork butcher holds considerable stocks of salt pork he requires larger pickling apparatus, and usually he has one or two tanks, built of slate or concrete—preferably the former—the cost of which may be from £5 to £10.

Pickling Pump. To hasten the salting process and make it more certain, he injects brine into the meat by means of a force-pump, and one of the best forms of brine-pump is that illustrated, the cost of which varies from £1 12s. 6d. to £3 3s., according to size and style of fittings.

Sausage Machinery. The hand machines recommended for the small beef butcher would not be of much use here, and an ordinary outfit would be the following.

	£	s.	d.
Silent meat-cutter of 25 lb. capacity	20	0	0
Two brake horse-power gas-engine	30	0	0
Pulley and belt	1	5	0
Delivering and fitting	10	0	0
Sausage filler of 30 lb. capacity ..	8	0	0
One 12 in. diameter bread press ..	3	0	0
Portable smoking oven ..	6	10	0
Cooking Outfit :			
One 50-gallon portable boiler	4	2	3
One 2 ft. 6 in. × 2 ft. 6 in. × 16in. gas roasting oven ..	19	15	0
Four baking-tins	1	6	0
Brisket press, 14 × 9 in. ..	1	5	0
One copper fork		1	3
Shop Outfit :			
One vegetable warmer ..	6	0	0
Meat and brisket stand, with marble block ..		16	0
Window fork ..		2	3
Two boning knives ..		2	6
Two butcher's knives ..		3	4
One cook's fork		1	6
Two choppers ..		7	0
Two block scrapers ..		3	0

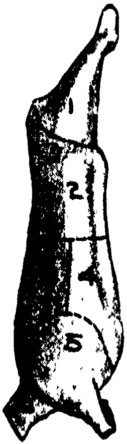
The weighing machine and weights, the steel, etc., would be the same as in a butcher's shop. The addition of a small scale and weights for seasonings would be an advantage and would cost about 25s.

The principal goods made by pork butchers are fresh pork sausages, fresh beef sausages, smoked sausages, or saveloys, small German sausages, large German sausages, brawn, and black puddings.

In the country it is usual to render lard, to pack and sell it in bladders or grease-proof paper bags, and to salt the legs into hams. The London trade does not do so, but cooks and sells hot roast and boiled pork and beef in various cuts, pease-pudding, baked potatoes, boiled carrots, cold boiled tongues, and various other occasional dishes.

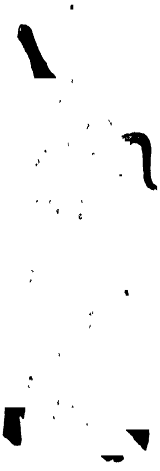
Pork Sausages. The fresh pork sausage is made pretty much like the fresh beef sausage, and the same general seasoning will be found suitable, with the addition of 3 oz. of rubbed sage and 1½ oz. of marjoram. The smoked sausages are frequently made of cheap, inferior meat, which is a pity, as a good smoked sausage will usually fetch its price (2d. a link) and bring customers back again. The German sausages contain varying quantities of farina as well as bread, and they are very finely chopped. The farina acts as a binder. The small "Germans" are usually of better quality, and are put up in *weasands*, which are the cleaned lining membrane of the ox's throat. The larger "Germans" are packed in *bungs*—the large intestine of the ox. Both are smoked. The general seasoning will suffice, the spicing being modified to suit the ideas of the maker and the taste of his customers. In the South of England, people, as a rule, do not care for too much spice in sausages, but in the North they cannot have too much.

Recipes. The following recipes for brawn and black puddings are taken from Douglas's "Encyclopædia of Butchery."



5. SIDE OF MUTTON

1. Leg. 2. Loin.
3. Neck.
4. Breast.
5. Shoulder.
6. Scrag End of Neck



6. SIDE OF PORK

1. Leg. 2. Loin.
3. Spring. 4. Hand.
5. Spare Rib. 6. Head

Brawn. Clean fresh pigs' heads well and bone them out. Begin with the cheeks first; take out the jaw-bones, and then the tongues, and then the eye-pieces. Get a small barrel and dust it with the following mixture: 5 lb. salt, ¼ lb. saltpetre, ½ lb. dry antiseptic. Rub the tongues, more specially at the roots. Put the tongues into the barrel first, then the cheeks, after dusting them over with the mixture, and lay them well over one another, rind to rind. Use the small pieces to fill in between. Between the layers dust freely the mixture, so that each portion of meat receives a covering. Keep the meat in the barrel for from twenty-four to thirty hours, then put it into a jacketed pan or boiling copper, with just sufficient clear water to cover the meat. Boil for an hour at 212° F., then remove on to a fine sieve, and strain out the jelly. Now cut the meat as nearly as possible into squares by means of a knife, or, better, by means of a brawn-cutting machine. When this is done, put your cut pieces into glass moulds or other suitable dishes, and fill up with the jelly previously strained off, and allow it to cool. Some prefer to keep a few tongues separate, and cut them into long pieces. These they stick down into the meat before the jelly is added. Some put in whole tongues. Seasoning for this brawn should be added when the meat is being boiled, and should be made on the following plan: For every 20 heads use 3 oz. white pepper, ½ oz. cayenne, a thimbleful of essence of lemon; a few cloves and some peppercorns throughout give a nice flavour.

Black Puddings. 10 lb. Midlothian groats, to be first boiled before mixing; 10 lb. leaf lard, or back fat; 1½ oz. black-pudding (herb) spice; 1½ oz. black pepper; 1 gallon blood (bullock's or pig's); a handful of chopped onions is sometimes added.

Boil the groats for about 40 minutes previous to using. Cut the leaf lard into pieces ¼ in. square with fat cutter. When the blood is being drawn from the bullock or pig it should be stirred gently, and a wineglassful of warm water added to every gallon, along with 2 oz. of salt and 2 oz. food preservative. Mix all the ingredients well together, placing them in a black-pudding filler, and fill the narrow bullock runners with the mixture. Tie pieces about 18 in. long into lengths, and bend them into circles, joining both ends. Boil them at a very gentle temperature (180° F.) for about 20 minutes, and then withdraw them from the pot or boiler and allow to cool.

During the process of boiling add to the water either 1 oz. (to every 10 gallons) of black-pudding dye, or ½ lb. of logwood chips, in order to dye them perfectly black. The old-fashioned way to tie black puddings is by means of dried rushes or bass strings, allowing the ends of the rushes to project about 3 in.

A valuable practical work for the butcher is that already referred to—Douglas's "Encyclopædia of Butchery," published at 10s., by William Douglas & Sons, Limited, of Putney.

Continued

Continued from page 1309

POETRY OF THE NINETEENTH CENTURY

2. The Successors of Wordsworth. A Short Study of Tennyson, with Briefer Notice of Browning, Swinburne, Matthew Arnold, and the lesser Victorian Poets

By J. A. HAMMERTON

The Significance of Tennyson. Mr. Theodore Watts-Dunton, poet and a critic of poetry, has summed up the significance of Wordsworth's great successor in a single telling phrase. "Tennyson," he writes, "knew of but one justification for the thing he said—*viz.*, that it was the thing he thought." ALFRED LORD TENNYSON (b. 1809; d. 1892) is the "bright particular star" in the crowded galaxy of Victorian poets. His muse was responsive to the dreams of science and the doubts of philosophy, as to the whole world of Nature. One of the most scholarly and exact of poets since Milton and Gray, he was, with the possible exceptions of Burns and Byron, the most popular since Shakespeare. Not even Wordsworth took his vocation more seriously. From a period of idealism he passed to one of something very like pessimism. Always hating the petty conventions of the present, he became in his later years too much of a social critic for his poetry to benefit. From first to last, however, he was a master of word-music, acutely sensitive to every vibration in Nature, and capable of rendering his impressions with almost miraculous fidelity. He saw no less clearly than he heard. Proctor said there were no mistakes about the stars in his poems; and similar tributes have been paid to his knowledge of birds and flowers.

The value of Tennyson to the student is twofold. On the one hand, he teaches by example the qualities and possibilities of the English language; on the other hand, his poems may not inaptly be described as "the voice of the century" in all its modulations between the extremes of buoyant hope and desolate despair. "In Memoriam," his elegiac poem, written in memory of his friendship for Arthur Hallam, son of the historian, has been much misrepresented as an influence against orthodox religion. Tennyson's faith was firm and unshaken to the [illegible] dreaded the dogmatism of sects [illegible] ions of God." "Locksley Hall," and its sequel, "Locksley Hall Sixty Years After," sum up the difference between liberal aspiration and democratic achievement. In "Maud," his favourite work, he entered an eloquent protest against the material views of human life.

The Poet's Views of Poetry. Tennyson's consistent contention was that poetry should be the flower and fruit of a man's life, and in every stage of it a worthy offering to the world. One day in the summer of 1888, in the garden of his home at Aldworth, Sussex, the Poet Laureate was discussing with Mr. Gosse the case of those who love to trace similarities, and seem to think that a mediocre poet who originates an idea is above the great poet who adopts and gives it everlasting form. Said Tennyson: "The dunces fancy it is the thought that makes poetry live. It isn't. It's the expression, the form; but we mustn't tell them so—they wouldn't know what we meant." This is a very different thing, of course, from saying that the "form" of poetry is its all in all; as the poet's further remark on the same occasion proves. "The highest poetry," he said, "may be popular, and praised in the magazines, and yet the secret of it is 'unrevealed to the whole godless world for ever.'" We may doubt if it is always revealed to the poet himself! But there is nothing in this view of poetry which is incompatible with the principles we have agreed upon at the outset of this course of study.

Tennyson and Modern Problems. If it be granted that Tennyson's poetry did not profit by his sensitiveness to the social problems of the time, or by the way in which he criticised the trend of policies and the fickleness of public opinion, it can hardly be gainsaid that he was a great teacher for all who care to give ear to his message. The best of Tennyson is not to be gathered by the pastime of hunting out plagiarisms from his poems. As the stirring events of Elizabeth's reign inspired Shakespeare, so was Tennyson inspired by the Battle of Waterloo and "the fairy tales of science" to the vision of a time when war-drums throbbed no longer—

> "And the battle-flags were furl'd
> In the Parliament of man, the Federation of
> the world."

But he saw the peril, first of an excessive "John Bullism," and then of mere "talk." A poet of Nature, Tennyson was also a lover, if a critic, of humanity and a prophet of social reform. The following quotation from "Locksley Hall Sixty Years After" shows this, as well as exemplifies the length to which he could carry his [illegible].

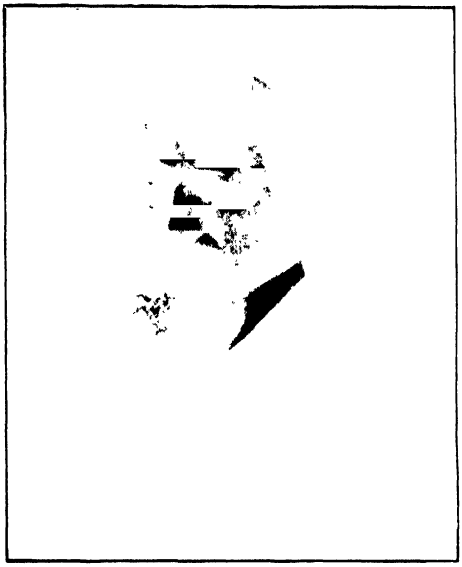
> "Is it well that while we range with Science,
> glorying in the Time,
> City children soak and blacken soul and
> sense in city slime?
> There among the glooming alleys Progress
> halts on palsied feet,
> Crime and hunger cast our maidens by the
> thousand on the street.
> There the master scrimps his haggard
> sempstress of her daily bread,
> There a single sordid attic holds the living
> and the dead.
> There the smouldering fire of fever creeps
> across the rotted floor,
> And the crowded couch of incest in the
> warrens of the poor."

In his interpretation of the five chief subjects it has been the province of poets to deal with—Nature, woman, life, politics, and religion—Tennyson will be found always looking forward to the ultimate good. If the spirit of the present generation wars with Tennyson the teacher, it is because of his treatment, in "The Princess" particularly, of "woman's rights." His views on "the woman question" were, indeed, reactionary. "Woman," he wrote,

"is not undevelopt man,
But diverse: could we make her as the man,
Sweet Love were slain: his dearest bond is this,
Not like to like, but like in difference."

The Metre of "In Memoriam." Tennyson is one of the most versatile of poets in his use of metre. "He realised," says Mr. Benson, "that the number of new thoughts that a writer can originate must be small—if, indeed, it is the province of a poet to originate thought at all—and the vital presentment, the crystalline concentration, of ordinary experience is what he must aim at." Hence his close attention to "form." "He always held, as he says in his poem 'To Virgil,' that the hexameter was the 'stateliest' metre ever invented; but he did not think it fit for English; he once said that it was only fit for comic subjects, and he believed that Englishmen confused accent with quantity. He indicated that quantity had so little existence in English that for practical purposes it was superseded by accent, and that, except for delicate effects, accent must be attended to; he always maintained that his experiments in classical metres had cost him more trouble than any of the poetry he had written." His son, the present Lord Tennyson, has an interesting chapter on "In Memoriam." The metre of this beautiful, if disjointed, elegy is the common long metre, with the second pair of rhymes indented. Here is a familiar example:

"I held it truth, with him who sings
To one clear harp in divers tones,
That men may rise on stepping-stones
Of their dead selves to higher things."



Elliott & Fry

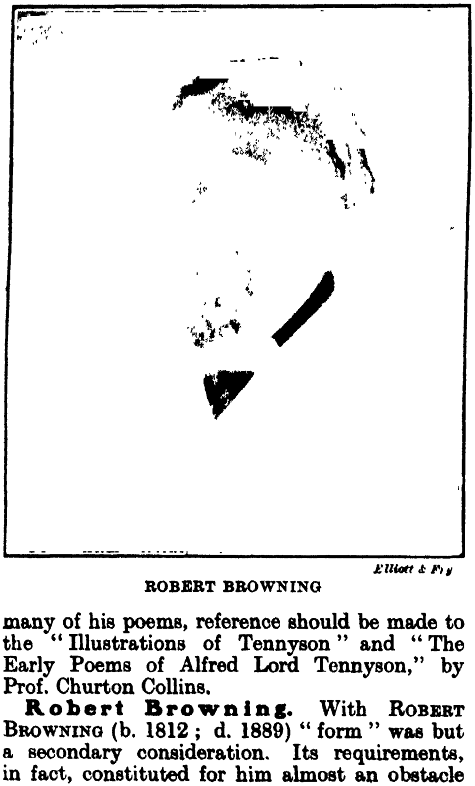
ALFRED LORD TENNYSON

Tennyson wrote: "As for the metre of 'In Memoriam,' I had no notion till 1880 that Lord Herbert of Cherbury had written his occasional verses in the same metre. I believed myself the originator of the metre, until after 'In Memoriam' came out [in 1850], when someone told me that Ben Jonson and Sir Philip Sidney had used it."

Under the Spell of the Poet. A friend, writing to the author of the "Life," records a remarkable incident which binds Froude the historian and a ship's mate by a bond of human fellowship, in their indebtedness to Tennyson's poetry. The incident is worthy of mention here as illustrating the power of the poet over readers of strangely different types. It is thus recorded in the official biography: "One moonlight night, when sailing, some years since, in the Malay Archipelago, I came on deck, to find the ship in charge of the mate, a taciturn mariner, uncouth, and of uncompromising visage. A chance remark, however, about the beauty of the night brought a line from a well-known stanza in 'In Memoriam' as reply. I completed the verse with undisguised pleasure, and this fairly broke the ice of his reserve. For the rest of that watch the mate paced up and down the deck, reciting to me the greater part of the 'Idylls' and the first half of 'Maud.' I shall never forget the feeling with which he lilted out the song, 'Birds on the high Wall Garden.' During the next week — 'all in the blue, unclouded weather' of that beautiful archipelago—the mate and I talked together on the one subject which had kept him, he averred, from suicide by drowning—a sailor's death more common than people think. For heart-whole delight in the poetry, for pure devotion to his image of the poet, I place that mate of a Malay coaster above all the Tennysonians I have met." Froude, writing in 1894, declared that he owed to Tennyson "the first serious reflections upon life and the nature of it," and that these had followed him for more than fifty years.

Tennyson's Favourite Poem and Some Others. From a technical standpoint "Maud" is regarded by competent criticism as one of the most perfect of Tennyson's great poems; it is the one, moreover, of which the poet himself was specially fond. It contains the exquisite lyric "Come into the Garden, Maud." Perhaps the best of Tennyson's work was his earliest. That which penetrates the heart of the many is comprised in the lyrics, such as the song just referred to, together with "Break, Break, Break," "Sweet and Low," and his swan song, "Crossing the Bar." But the "Idylls of the King" are also widely loved. Mr. Benson places "The Lady of Shalott," "Mariana in the South," "The Miller's Daughter," "Œnone," "The Palace of Art," "The May Queen," "The Lotos Eaters," "A Dream of Fair Women," "The Morte d'Arthur," "Love and Duty," and "Locksley Hall" among the poems which have "profoundly affected English literature."

How to Study Tennyson. The best plan to pursue in the study of Tennyson is to take up the "Life" of the poet written by his son, and then to read the poems in the sequence in which they were written. Any student who will do this will know more of Tennyson (and, incidentally, of the most important of his contemporaries) than he will be able to glean from any other pair of volumes that can be named. For examples of (1) Tennyson's indebtedness to the writers who preceded him, and (2) the extent to which he re-wrote many of his poems, reference should be made to the "Illustrations of Tennyson" and "The Early Poems of Alfred Lord Tennyson," by Prof. Churton Collins.



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ROBERT BROWNING

Robert Browning. With ROBERT BROWNING (b. 1812; d. 1889) "form" was but a secondary consideration. Its requirements, in fact, constituted for him almost an obstacle to the flow of thought. He is as difficult and obscure as, for the most part, Tennyson is clear and easy to the common understanding. It is said that in the course of time Browning will supersede his great contemporary in popular estimation; but that time is not yet, nor likely soon to come. With Browning, far more than with Tennyson, is it necessary to consider the life and the poetry as interdependent and inter-explanatory. It has been well said that "much of the apparent obscurity of Browning is due to his habit of climbing up a precipice of thought, and then kicking away the ladder by which he climbed."

There is no gloom in Browning. He is all virility. His dramas and his poems are the appurtenances of an intellectual gymnasium. With Browning—

"Life is—to wake, not sleep."

"Rise and not rest," he cries; but "press—

"From earth's level where blindly creep
Things perfected, more or less,
To the heaven's height, far and steep,
Where, amid what strifes and storms
May wait the adventurous guest,
Power is love."

Tennyson wrote that:

"'Tis better to have loved and lost
Than never to have loved at all."

With Browning it is better to have lived and struggled and failed than never to have lived at all.

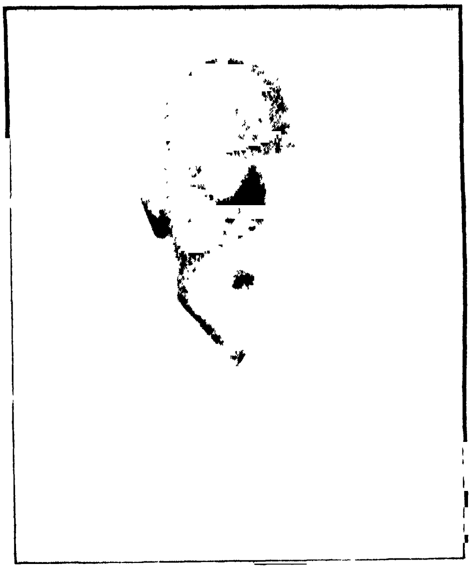
Browning as a Poet. "Browning as a poet," writes Prof. Dowden, his most competent critic, "had his origins in the romantic school of English poetry; but he came at a time when the romance of external action and adventure had exhausted itself, and when it became necessary to carry romance into the inner world, where the adventures are those of the soul. On the ethical and religious side he sprang from English Puritanism. Each of these influences was modified by his own genius and by the circumstances of its development. His keen observation of facts and passionate inquisition of human character drew him in the direction of what is termed realism. . . . His Puritanism received important modifications from his wide-ranging artistic instincts and sympathies, and again from the liberality of a wide-ranging intellect. . . . He regarded our life on earth as a state of probation and of preparation. . . . In his methods Browning would acknowledge no master; he would please himself and compel his readers to accept his method, even if strange or singular. . . . His optimism was part of the vigorous sanity of his moral nature; like a reasonable man, he made the happiness which he did not find. . . . The emotions which he chiefly cared to interpret were those connected with religion, with art, and with the relations of the sexes.

. . "His humour was robust, but seldom fine or delicate. . . . There is little repose in Browning's poetry. He feared lethargy of heart the supine mood, more than he feared excess of passion. . . . His utterance, which is always vigorous, becomes intensely luminous at the needful points, and then relapses to its well-maintained vigour, a vigour not always accompanied by the highest poetical qualities. The music of his verse is entirely original, and so various are its kinds, so complex often are its effects, that it cannot be briefly characterised. Its attack upon the ear is often by surprises, which, corresponding to the sudden turns of thought and leaps of feeling, justify themselves as right and delightful. Yet he sometimes embarrasses his verse with an excess of suspensions and resolutions. Browning made many metrical experiments, some of which were unfortunate, but his failures are rather to be ascribed to temporary lapses into a misdirected ingenuity than to the absence of metrical feeling. His chief influence, other than what is purely artistic, upon a reader is towards establishing a connection between the known order of things in which we live and move, and that larger order of which it is a part."

An Important Point. It is especially important to remember that Browning's thought where it is most significant is often more or less enigmatical if taken by itself; "its energetic gestures, unless we see what they are directed against, seem aimless beating in the air." That portion of his work, therefore, which is primarily polemical bids fair to fail of interesting posterity. "Men and Women" includes some of his finest work; but his masterpiece is the living human epic of "The Ring and the Book." "How they Brought the Good News from Ghent," "Saul," "The Lost Leader," and "The Pied Piper of Hamelin," are among his most popular works. It is worthy of note, by the way, that the first book of "Selections from Browning" was issued at the request of a society of literary students meeting weekly in Whitechapel, and it would be no bad plan if the young student first approached Browning's poetry by the reading and re-reading of this admirable selection of his writings. It would prepare him in a measure for the strikingly individual qualities of the poet's longer works and give him a good idea of the bent of Browning's mind.

Algernon Charles Swinburne (b. 1837). Mr. Swinburne's peculiar ideas, republican and agnostic, though popular opinion concerning them is to a certain extent misguided, have certainly had the effect of keeping the greatest living lyrist from the Laureateship In both his prose and his verse Mr. Swinburne seems ever at the mercy of an irrepressible flow of language. He exaggerates whatever he touches. In the main, the exaggeration makes genuine poetry, if we consider poetry as devoid of all appeal except the appeal to the ear and the passions. But in some of his works, and notably in "Poems and Ballads" legitimate exaggeration ranges into regrettable licence, if not utter unintelligibility. Mr. Swinburne has yet to be recognised for his essential patriotism as he is admired for his songs of the sea. His verse is as near to actual music as that of any poet who ever lived. Reference has been made to Tennyson's facile use of varied metres; but in this regard Swinburne is the more comprehensive artist.

The More Important of the Minor Poets. Next in importance to Mr. Swinburne must be reckoned Matthew Arnold (b. 1822; d. 1888), whose poems, austere in form, classic in spirit, breathe the indefinable sadness of culture threatened by anarchy. Mr. Swinburne has uttered no criticism that rings more truly than his dictum that Matthew Arnold's "best essays ought to live longer than most; his poems cannot but live as long as any of their time." Matthew Arnold would have won lasting distinction among the few had he only written "The Strayed Reveller," "Empedocles on Etna," "The Scholar Gipsy," and "Sohrab and Rustum." The poems of Frederick Tennyson (b. 1807; d. 1898) and Charles Tennyson Turner (b. 1808; d. 1879) may be studied with those of their illustrious brother. Frederick was joint author of the famous "Poems of Two Brothers," and his "Isles of Greece" is a poem well worth study. Charles is best represented by his sonnets. Dante Gabriel Rossetti (b. 1828; d. 1882) cannot, as Mr. Benson observes, be said to have modified in any direct way the great stream of English poetry; but he "has stimulated the sense of beauty, the desire to extract the very essence of delight from emotion, form and colour; he has inculcated devotion to art." Christina Rossetti (b. 1830; d. 1894) takes a place in English literary history by the side of Mrs. Browning and Jean Ingelow (b. 1820; d. 1897). A. H. Hallam (b. 1811; d. 1833) lives in "In Memoriam" as John Sterling does in Carlyle's biography. Richard Monckton Milnes, Lord Houghton (b. 1809; d. 1885), belongs to the school of Praed and F. Locker-Lampson (b. 1821; d. 1895) as a brilliant writer of society verse. William E. Aytoun (b. 1813; d. 1865) was the author of "Lays of the Scottish Cavaliers." Aubrey de Vere (b. 1814; d. 1902), the son of Sir Aubrey de Vere, was, like his father, a successful sonneteer, but is more noteworthy as a critic and a friend of Tennyson. Charles Mackay (b. 1814; d. 1889) wrote the well-known lyric of "Tubal Cain." Philip James



Elliott & Fry

ALGERNON CHARLES SWINBURNE

BAILEY (b. 1816; d. 1902) spent his life in the development of his dramatic poem of "Festus," which, now half forgotten, was once hailed as the product of the highest poetic genius. JAMES WESTLAND MARSTON (b. 1820; d. 1890) wrote a number of dramas and poems that are now but imperfectly remembered. Of his son, PHILIP BOURKE MARSTON (b. 1850; d. 1887), the blind poet, it may indeed be said that he learnt in suffering what he taught in song. Both JOHN RUSKIN (b. 1819; d. 1900) and GEORGE MEREDITH (b. 1828) are greater poets in their prose than in their verse. ARTHUR HUGH CLOUGH (b. 1819; d. 1861), as shown by "The Bothie of Tober-na-Vuolich," was not altogether given over to the philosophic doubt usually associated with his name. CHARLES KINGSLEY (b. 1819; d. 1875) should be praised for his "Andromeda" as well as for such lyrics as "Oh, that We Two were Maying," "The Sands of Dee," and "Three Fishers went Sailing," and his breezy "Ode to the North-East Wind." COVENTRY PATMORE (b. 1823; d. 1896) is seen at his best in the refined sympathy of "The Angel in the House," and "The Unknown Eros." In the Irish songs of WILLIAM ALLINGHAM (b. 1824; d. 1889) is to be traced something of the origin of the present "Celtic revival." The poetic output of ROBERT LOUIS STEVENSON (b. 1850; d. 1894), limited in quantity, is notable in quality. GEORGE MACDONALD (b. 1824; d. 1905) wrote many short lyrics, of which "Baby" is especially delightful. His "Diary of an Old Soul" was declared by Ruskin to be one of the three great religious poems of the century. FRANCIS TURNER PALGRAVE (b. 1824; d. 1897) was greater as a critic than as a poet; his "Golden Treasury of Songs and Lyrics" bears witness to his powers of discrimination, though he owed much to the advice of Tennyson. GERALD MASSEY (b. 1828), the original of George Eliot's "Felix Holt," long since laid aside the lyre; but his poems rank among the best that are "racy of the soil" and expressive of that popular spirit which gave rise to Chartism. Sir EDWIN ARNOLD (b. 1832; d. 1904), in his "Light of Asia," interpreted Buddhism for Western readers. Sir LEWIS MORRIS (b. 1833) is the author of a poem called "The Epic of Hades," But WILLIAM MORRIS (b. 1834; d. 1896), as seen in his "Earthly Paradise," was a poet of a much more considerable calibre. Anglo-India has inspired Sir FRANCIS HASTINGS DOYLE (b. 1810; d. 1888), Sir ALFRED LYALL (b. 1835) and Mr. RUDYARD KIPLING (b. 1865). Mr. Kipling's "Barrack-room Ballads" and the poem entitled "Recessional" exhibit him in two widely different moods. JAMES THOMSON, "B.V." (b. 1834; d. 1882), depicted the dark side of London in "The City of Dreadful Night," and ranks with Philip Marston among the unfortunates of genius. ROBERT BUCHANAN (b. 1841; d. 1901) is another example of unfulfilled promise, but his early poems will one day be the object of the admiration they deserve. WILLIAM ERNEST HENLEY (b. 1849; d. 1903) is the Heine of England; his "Book of Verses," "In Hospital," and "London Voluntaries," occupy a distinctive place in latter-day literature. To living poets, beyond those already mentioned, it is impossible to do justice. Of Mr. ALFRED AUSTIN (b. 1835) it can at least be said that his love of Nature is genuine, and his lyrical gift, if unequal, certainly above the contempt that has been heaped upon it. Dr. RICHARD GARNETT (b. 1835) is a poet as well as a critic. Mr. AUSTIN DOBSON (b. 1840) and Mr. EDMUND GOSSE (b. 1849) are two of our sweetest and least pretentious singers. Mr. THEODORE WATTS-DUNTON (b. 1832) has written many sonnets of exceeding beauty. Of Mr. W. S. BLUNT (b. 1840) much the same may be said. Mr. W. B. YEATS (b. 1865), Mr. JOHN DAVIDSON (b. 1857), who is still writing "Fleet Street Eclogues," Mr. HENRY NEWBOLT (b. 1862), and Mr. LAURENCE BINYON (b. 1869) all claim mention. But Mr. ROBERT BRIDGES (b. 1844) is, of all our minor poets, perhaps the one whose work will prove the most enduring. If he is challenged for supremacy it will be by Mr. WILLIAM WATSON (b. 1858). Among our women poets, Mrs. ALICE MEYNELL is undoubtedly the foremost. She is, indeed, one of the greatest women writers of the century, with an individual and memorable voice.

This brief summary is by no means exhaustive; but it will afford the student a clue to the most distinctive poets of the past century.

Books to Read. For biography there is no series cheaper or better than the "English Men of Letters" (Macmillan). The Tennysonian student, however, must read the standard "Memoir" by the present Lord Tennyson (now published by Macmillan at 6s.) and, in addition to the works mentioned in the text, would do well to consult the amended edition of "In Memoriam" (Macmillan. 5s.), and Mr. A. C. Benson's "Tennyson" in Methuen's "Little Biographies" (3s. 6d.). The best biography of Browning is by Prof. Dowden (Dent. 4s. 6d.). There is no cheap complete edition of his works; but Messrs. Smith, Elder publish a small volume of "Selections" at 1s.; and the whole of the works in eight pocket volumes at 2s. 6d. each. Mr. Swinburne's "Poems" and "Tragedies" have been recently issued in a uniform edition by Messrs. Chatto & Windus. The "Globe" series (Macmillan), the "Oxford Poets" (Frowde), the "Aldine Poets" (Bell), and "The Muses Library" (Routledge) supply admirable texts of most of the standard poets mentioned in this and the preceding part of our study. The best edition of Wordsworth is edited by Prof. Knight (Macmillan), who has also arranged a commendable selection of "The Best Poems" (Newnes. 3s. 6d.). The new copyright edition of Byron's works, edited, with a racy memoir, by Mr. Ernest Hartley Coleridge, and published, at 6s., by Mr. John Murray is, for obvious reasons, the best. Matthew Arnold's poems have been issued by Messrs. Walter Scott and Messrs. Routledge in inexpensive form. Consult also the "Canterbury Poets" and "Poets and Poetry of the Nineteenth Century," edited by A. H. Miles.

Continued

SQUARE ROOT & CUBE ROOT

Methods of Extracting Square Root and Cube Root, and the Principles on which these Methods are Based. Measurement of Surface

Continued from page 1264

By HERBERT J. ALLPORT, M.A.

SQUARE ROOT

140. If a number can be put into prime factors, its square root can be written down by inspection.

Example. Find the square root of 27225.

$$\begin{array}{r|r} 3 & 27225 \\ \hline 3 & 9075 \\ \hline 5 & 3025 \\ \hline 5 & 605 \\ \hline 11 & 121 \\ \hline & 11 \end{array}$$

Hence $27225 = 3^2 \times 5^2 \times 11^2$.

$\therefore \sqrt{27225} = 3 \times 5 \times 11 = \underline{165}$ *Ans.*

141. We know that $\sqrt{1} = 1$, and $\sqrt{100} = 10$. Therefore, the square root of any number which lies between 1 and 100 lies between 1 and 10, *i.e.*, if a number contains *one* or *two* digits, its square root consists of *one* digit.

Similarly, since $\sqrt{100} = 10$ and $\sqrt{10000} = 100$, the square root of a number between 100 and 10000 lies between 10 and 100. That is, if a number contains *three* or *four* digits, its square root consists of *two* digits.

Proceeding in this way, we obtain a general result—*viz.*, the square of a number has either twice as many digits as the number, or one less than twice as many.

Hence, to ascertain the number of digits in the square root of a perfect square, mark off the digits in pairs, beginning from the right. Each pair marked off gives a digit in the square root; and, if there is an odd digit remaining, that digit also gives a digit in the square root.

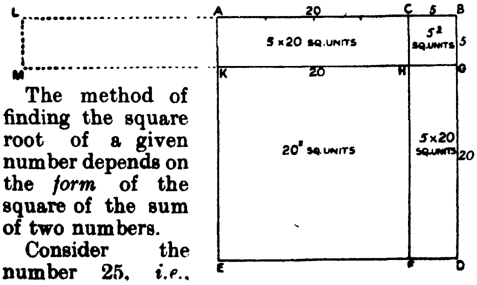
Example 1. How many digits are there in the square root of 546121 ?

Marking pairs of digits from the right we get 54,61,21.

There are, therefore, *three* digits in the square root.

Example 2. How many digits are there in the square root of 5774409 ?

Marking off as before, we get 5,77,44,09, so that there are three pairs of digits, and one digit remaining. Hence, there are *four* digits in the square root.



The method of finding the square root of a given number depends on the *form* of the square of the sum of two numbers.

Consider the number 25, *i.e.*, 20 + 5. In the figure, let AB measure 25 units and BC 5 units. Then AC = 20 units. Draw the square ABDE, and draw CF parallel to BD.

Make BG = 5 units, and draw GK parallel to AB. Then it is easily seen that (1) ABDE contains 25^2 square units; (2) BCHG contains 5^2 square units; (3) each of the figures ACHK, GHFD, contains 5 × 20 square units; (4) HKEF contains 20^2 square units.

It follows that

$$25^2 = (20+5)^2 = 20^2 + \text{twice } 20 \times 5 + 5^2.$$

The result may be written in the form

$$25^2 = 20^2 + (\text{twice } 20 + 5) \times 5.$$

This is easily seen by transferring HGDF into the position shown by the dotted lines. For the square on AB is then equal to the two figures HKEF and LBGM. And, since AL = 20 units, AC = 20 units, and CB = 5 units, therefore, LB = (twice 20 + 5) units. Hence, the figure LBGM contains (twice 20 + 5) × 5 sq. units.

142. Suppose we are required to find the square root of 625. Marking off the digits, as in Art. **141**, we see that there will be two digits in the square root. The greatest perfect square which is not greater than 6 is 4, *i.e.*, 2^2. Hence, 2 is the first, or ten's, figure of the square root. Subtract, then, this 20^2 from 625. The remainder is 225. Now, by Art. **141**, if our given number is a perfect square, this remainder must be equal to (twice 20 + digit required) × that digit. Twice 20, or 40, is, therefore, a *trial divisor*. Now, 40 divided into 225 gives 5 for quotient. We therefore try whether (40 + 5) × 5 is equal to 225; and, finding this to be the case, we know that 5 is the digit we wanted, and that the square root of 625 is 25.

We shall now consider a somewhat longer example, and show the method in which the work is arranged.

Example 1. Find the square root of 74529.

$$\begin{array}{rl} & 7,45,29(200 + 70 + 3 \\ 200^2 = & \underline{4\ 00\ 00} \\ & 3\ 45\ 29 \\ 70 \times (\text{twice } 200 + 70) = & \underline{3\ 29\ 00} \\ & 16\ 29 \\ 3 \times (\text{twice } 270 + 3) = & \underline{16\ 29} \end{array}$$

Explanation. We see that there will be three digits in the square root. The greatest square number less than 7 is 4, *i.e.*, 2^2. Hence, 2 is the hundred's figure of the square root. We therefore subtract 200^2, and obtain a remainder 34529. We now have twice 200, *i.e.*, 400, for a trial divisor; and 400 divided into 34529 gives 80. By trial, we find 80 is too large, since [illegible]ry (b. 181[illegible]) is greater than 34529. We there[illegible] 70. This gives $70 \times (400 + 70) = 3290$[illegible] this, when subtracted from 34529, leaves 1629.

We have now completed the subtraction of 270^2 from the original number, and found a remainder 1629.

Next, use twice 270, *i.e.*, 540, for a trial divisor. 540 into 1629 gives 3. And $3 \times (540 + 3) = 1629$, so that, after subtraction, there is no remainder.

Also, since [Art. **141**] $273^2 = 270^2 +$ (twice $270 + 3) \times 3$, we have now subtracted 273^2 from the given number 74529. Hence, as there was no remainder, we know that $273^2 = 74529$, so that the required square root is 273.

The working is abbreviated as follows :

```
      7,45,29(273 Ans.
47)3 45
54 3)16 29
```

Explanation. As above, we find the first digit of the answer is 2. Square 2, and subtract from 7, in one process. Remainder is 3. Write the next pair of digits, 45, after the 3, giving 345.

Double the digit of the answer, which has already been found, obtaining 4 as a trial divisor. 4 into 34 gives 8, which, as we saw above, is too large. Try 7. This proves small enough, so we write the 7 after the 4 of our trial divisor, and put 7 into the answer. Multiply 47 by 7 and subtract from 345. Remainder is 16. Bring down the remaining two digits, 29, of the given number. Double the 27 of the answer, obtaining 54 as trial divisor. 54 into 162 gives 3. Write 3 after the 54 and 3 in the answer. Multiply 543 by 3 and subtract from 1629. There is no remainder, and 273 is the required square root.

Example 2. Find the square root of 2310·7249

```
       23,10·72,49,(48·07 Ans.
88   ) 7 10
9607 )  6 72 49
```

Mark off the digits in pairs *from the decimal point*. Proceed as in Example 1. After obtaining the first two figures of the square root, 48, we reach the decimal point in the given number. We therefore put a decimal point in the answer, and bring down the next two figures, 72. The trial divisor is 96, and 96 into 67 gives 0. Put 0 in the answer, and bring down 49. The trial divisor is now 960, and this gives 7 for the remaining digit.

148. In the case of a number which is not a perfect square, the process of finding the square root can be continued to as many decimal places as we please, but never terminates.

The square root will not be a recurring decimal, for a recurring decimal can be expressed as a vulgar fraction in its lowest terms ; and, if we square such a fraction, the numerator and denominator will still be prime to one another—*i.e.*, the square is a *fraction*, and so, of course, cannot be equal to the given number.

Example. Find the value of $\sqrt{2}$ to four places of decimals.

```
  2   (1·4142 Ans.
24)100
281 )400
2824)11900
28282 )60400
        3836
```

We consider that 2 is 2·0000... and bring down 00 at each stage of the work.

A number such as $\sqrt{2}$, or $\sqrt{5}$, which cannot be exactly expressed as a decimal is called an *Incommensurable Number*, or a *Surd*.

144. To obtain the square root of a vulgar fraction we take the square root of the numerator and the square root of the denominator.

For, the square of $\frac{3}{4}$ is $\frac{3}{4} \times \frac{3}{4}$, *i.e.*, $\frac{9}{16}$. Therefore,

$$\sqrt{\frac{9}{16}} = \frac{3}{4} \text{ or } \frac{\sqrt{9}}{\sqrt{16}}.$$

In the case of a mixed number, we reduce it to an improper fraction and proceed in the same way.

Example 1. Find the square root of $19\frac{30}{49}$.

$$19\tfrac{30}{49} = \tfrac{961}{49}.$$

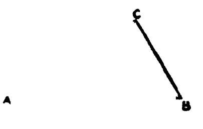
$$\therefore \text{ Square root} = \frac{\sqrt{961}}{\sqrt{49}} = \frac{31}{7} = \underline{4\tfrac{3}{7}\ \textit{Ans.}}$$

If the denominator is not a perfect square, we multiply both numerator and denominator by such a number as will make the denominator a perfect square.

Example 2. Find the square root of $\frac{3}{5}$, to three places of decimals.

$$\sqrt{\frac{3}{5}} = \sqrt{\frac{3 \times 5}{5 \times 5}} = \sqrt{\frac{15}{25}} = \frac{\sqrt{15}}{5} = \frac{3{\cdot}872\ldots}{5}$$
$$= \underline{{\cdot}774 \ldots \textit{ Ans.}}$$

145. **Applications of Square Root.** In the course on GEOMETRY it will be proved that if one angle of a triangle is a right angle then the square on the side opposite the right angle is equal to the sum of the squares on the other two sides. This property enables us to find the length of the third side of a right-angled triangle when we know the lengths of the other two sides.



Thus, if the angle C is a right angle, and we know that BC = 3 and CA = 4, then

$$AB^2 = 3^2 + 4^2 = 9 + 16 = 25.$$
$$\therefore AB = \sqrt{25} = 5.$$

Or, if we know that AB = 37 and AC = 35, then

$$BC^2 = AB^2 - AC^2 = 37^2 - 35^2 = 144.$$
$$\therefore BC = \sqrt{144} = 12.$$

Example. How long is the diagonal of a rectangular field whose length is 153 yd. and breadth 104 yd. ?

$$\begin{aligned}\text{The square of the diagonal} &= 153^2 + 104^2\\ &= 23409 + 10816\\ &= 34225.\end{aligned}$$
$$\therefore \text{ Diagonal} = \sqrt{34225} = 185 \text{ y}\cdot \underline{\textit{Ans.}}$$

146. The following is a common type of problem in square root.

Example. The members of a club each subscribed as many sixpences as there were members of the club. The total sum was £455 12s. 6d. How many members were there ?

$$\begin{array}{rl}
\text{£ \ \ s. \ d.} & \\
455 \ \ 12 \ \ 6 & \\
\underline{20} & \\
\underline{9112} & \text{s.} \\
\underline{2} & \\
\overline{1,82,25} & \text{sixpences } (\underline{135 \text{ members } \textit{Ans.}}) \\
23)\overline{\ 82} & \\
265)\ 13\ 25 &
\end{array}$$

Explanation. Evidently the number of sixpences subscribed is the square of the number of members. We therefore reduce the given sum to sixpences, and find the square root.

Other problems will be met with after the chapter on Areas and Volumes.

CUBE ROOT

147. If we can find the prime factors of any perfect cube, we can write down its cube root by inspection.

Example. Find the cube root of 74088.

$$\begin{array}{r|l}
8 & 74088 \\
9 & \underline{\ 9261} \\
3 & \underline{\ 1029} \\
7 & \underline{\ \ 343} \\
7 & \underline{\ \ \ 49} \\
 & \ \ \ \ \ 7
\end{array}
\qquad
\begin{array}{l}
\therefore\ 74088 = 8 \times 9 \times 3 \times 7 \times 7 \times 7 \\
\qquad\qquad = 2^3 \times 3^3 \times 7^3 \\
\therefore\ \sqrt[3]{74088} = 2 \times 3 \times 7 \\
\qquad\qquad = \underline{42\ \textit{Ans.}}
\end{array}$$

148. Since $1^3 = 1$ and $10^3 = 1000$, therefore, the cube of a number which lies between 1 and 10 lies between 1 and 1000, *i.e.*, the cube of a number of one digit contains either one, two, or three digits.

Again, since $10^3 = 1000$ and $100^3 = 1000000$, the cube of a number of two digits contains either four, five, or six digits.

Proceeding in this way, we see that *the cube of a number contains three times, or one less or two less than three times, as many digits as the number.*

Hence, to find the number of digits in the cube root of a given number, we mark off the digits in sets of three, beginning at the decimal point, and marking both to the right and to the left.

149. The simplest method of finding the cube root of numbers whose prime factors are not known is analogous to the method of finding square root, being based upon the form of the cube of the sum of two numbers.

The student can easily verify for himself that

$$\begin{aligned} 67^3 &= 60^3 + 3 \times 60^2 \times 7 + 3 \times 60 \times 7^2 + 7^3 \\ &= 60^3 + (3 \times 60^2 + 3 \times 60 \times 7 + 7^2) \times 7. \end{aligned}$$

If, then, from some given number, we first subtract 60^3, and then subtract $(3 \times 60^2 + 3 \times 60 \times 7 + 7^2) \times 7$, we shall, altogether, have subtracted 67^3. If we now have no remainder we conclude that the given number is 67^3, *i.e.*, that its cube root is 67.

It should be noticed that 3×60^2 is the same thing as $6^2 \times 300$, and that $3 \times 60 \times 7$ is the same as $6 \times 30 \times 7$. In working examples we shall use the second of these forms, as there is possibly less chance of the student making any mistake in forming the "trial divisors."

By multiplication we know that $67^3 = 300763$. Let us consider how, when we are only given the number 300763, we find that its cube root is 67.

$$\begin{array}{rr|l}
 & & 300,763(67 \\
6^3 = & & \underline{216} \\
6^2 \times 300 = & 10800 & \ \ 84\,763 \\
6 \times 30 \times 7 = & 1260 & \\
7^2 = & \underline{49} & \\
 & 12109 & \underline{84\,763}
\end{array}$$

We first mark off the digits in threes, beginning at the decimal point—*i.e.*, in this case, at the right-hand digit. Next, we know that $6^3 = 216$, and $7^3 = 343$. Hence, since 300 lies between these numbers, we know that the first digit of our answer is 6. Write the 216 under the 300, and subtract. In reality, of course, we are subtracting 60^3 from 300763. The remainder is 84763. We now form our trial divisor, by squaring the digit already found and multiplying by 300 [see above]. Thus, $6^2 \times 300 = 10800$. Now 10800 into 84763 appears to give 7 for the next digit of our answer. We try 7, forming the rest of our divisor by taking $6 \times 30 \times 7 = 1260$, and $7^2 = 49$, and adding the three lines. This gives 12109, and, on subtracting 7 times 12109 from 84763, there is no remainder. Hence, 67 is the required cube root.

Example. Find the cube root of 14706·125.

$$\begin{array}{rr|l}
 & & 14,706{\cdot}125,(\underline{24{\cdot}5\ \textit{Ans.}} \\
2^3 = & & \ \ \underline{8} \\
2^2 \times 300 = & 1200 & \ \ 6\,706 \\
2 \times 30 \times 4 = & 240 & \\
4^2 = & \underline{16} & \\
 & 1456 & \ \ \underline{5\,824} \\
24^2 \times 300 = & 172800 & 882\,125 \\
24 \times 30 \times 5 = & 3600 & \\
5^2 = & \underline{25} & \\
 & 176425 & \underline{882\,125}
\end{array}$$

Explanation. Mark off the digits in threes. By inspection, the first digit of the answer is 2. Subtract 2^3 from 14, obtaining remainder 6. Bring down the next set of digits, making 6706. Form the next divisor by taking $2^2 \times 300 = 1200$. This, divided into 6706, would appear to make the next digit of the answer be 5. If, however, we use 5, and complete the divisor, we find that 5 is too big. Try 4, *viz.*, $2 \times 30 \times 4 = 240$, and $4^2 = 16$. Adding, the divisor is 1456. Subtract 4 times 1456 from 6706. The remainder is 882. Bring down the next set of digits, 125, and, since these digits form the decimal part of the given number, we put a decimal point in the answer. Proceed as before—*i.e.*, square the part of the answer already found, and multiply by 300. Thus, $24^2 \times 300 = 172800$. Dividing this into 882125 gives 5 for quotient, and we complete the divisor by taking $24 \times 30 \times 5 = 3600$, and $5^2 = 25$, which, on addition, makes 176425. Subtract 5 times 176425 from 882125, and there is no remainder. Hence the required cube root is 24·5.

150. A great amount of labour can be saved in forming the trial divisors, after the first. Thus, in the previous example, the second trial divisor, 172800, can be found without working out the value of $24^2 \times 300$.

$$\left.\begin{array}{rr} 2 \times 30 \times 4 = & 240 \\ 4^2 = & \underline{16} \\ & 1456 \\ \text{Repeat } 4^2 = & \underline{16} \end{array}\right\} \\ 24^2 \times 300 = 172800$$

The rule is as follows: In the first divisor, already obtained, repeat the $4^2 = 16$, and add together everything but the first trial divisor, 1200. This gives 1728. *If we now add two noughts we obtain the value of* $24^2 \times 300$.

The necessary figures are shown above, bracketed together, but, of course, in actual work, we repeat the 16 mentally, and write down nothing more than was shown in the working of the example.

151. The cube root of a number which is not an exact cube, can be found to any required number of decimal places. If the decimal part of the given number does not contain an exact number of sets of three digits, we simply put on ciphers to make up the set, and, of course, use three ciphers for each succeeding set that may be required.

Example. Find the cube root of 4·9590954051 to four places of decimals.

$$\begin{array}{rrl} & & 4{\cdot}959,095,405,100,(\underline{1{\cdot}7053\ldots} \\ & & 1 \qquad\qquad\qquad\qquad \underline{\textit{Ans.}} \\ 1^2 \times 300 = & 300 & 3\,959 \\ 1 \times 30 \times 7 = & 210 & \\ 7^2 = & \underline{49} & \\ & 559 & \underline{3\,913} \\ 170^2 \times 300 = & 8670000 & 46\,095\,405 \\ 170 \times 30 \times 5 = & 25500 & \\ 5^2 = & \underline{25} & \\ & 8695525 & \underline{43\,477\,625} \\ 1705^2 \times 300 = & 872107500 & 2617\,780\,100 \\ 1705 \times 30 \times 3 = & 153450 & \\ 3^2 = & \underline{9} & \\ & 872260959 & \underline{2616\,782\,877} \\ & & 997\,223 \end{array}$$

Explanation. After obtaining the first two figures, 17, of the answer, the remainder is 46. Bringing down the next three figures we obtain 46095. Our trial divisor (obtained as already explained, by adding together 210, 49, 559, and 49, and affixing two noughts) is 86700. This, divided into 46095, evidently gives 0 for the next figure of the answer. Therefore, after putting 0 in the answer, we bring down the next three figures, and obtain 46095405. The trial divisor is now $170^2 \times 300$, which means we have simply to put two more noughts on to the 86700 already obtained. We then proceed as before. Our final trial divisor, *viz.*, $1705^2 \times 300$ is obtained from the preceding divisor, by adding 25500, 25, 8695525, 25, and affixing two noughts.

EXAMPLES 18

By the method of factors, find the value of

1. $\sqrt{74529}$.
2. $\sqrt{4624}$.
3. $\sqrt{27300625}$.
4. $\sqrt[3]{113533}$.
5. $\sqrt[3]{18369744}$.
6. $\sqrt[3]{1520875}$.
7. Find the square root of 98765·6329.
8. Find the square root of $3\frac{1}{4}$ correct to three places of decimals.
9. Find the cube root of 30959144, and of 9269337·400720047.
10. Find the cube root of $13\frac{203}{512}$.
11. The side of a square is 5 ft. Find, to three places of decimals, the length of the diagonal.
12. A man spent £19 5s. 4d. in buying books. On the average, each book cost as many pence as there were books. How many books did he buy ?
13. On a tour, a man spent each day 5 times as many sixpences as the number of days the tour lasted. If he spent, in all, £6 2s. 6d., how long did the tour last ?
14. The foot of a ladder 50 ft. long is 14 ft. from the wall of a house, and its other end just reaches the top of a window. When the foot of the ladder is moved to a distance of 30 ft. from the wall, the other end just reaches the bottom of the window. What does the window measure from top to bottom ?

MEASUREMENT OF SURFACE

152. The table used for measuring *area*, or surface, is given on page 226.

The chief surface with which we are concerned in arithmetic is the *rectangle*.

A rectangle is a four-sided figure in which each side is equal in length to the opposite side, and each of the angles is a right angle.

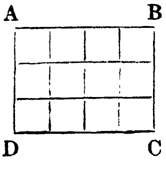
The length and breadth of a rectangle are called its *dimensions*.

If the length and breadth of a rectangle are equal, the figure is called a *square*. We see, then, that the unit of surface, the *square foot* mentioned in the tables, means a square surface, each of whose sides measures a linear foot. Similarly, a square surface which measures a linear inch on each side is called a square inch, and a square surface which measures a linear yard on each side is called a square yard.

153. The number of square feet (or inches, or yards) in the area of a rectangle is equal to the number of linear feet (or inches, or yards) in the length multiplied by the number of linear feet (or inches, or yards) in the breadth.

This statement is usually abbreviated into

Length × Breadth = Area.



For, let ABCD be a rectangle whose length, AB, is 4 ft., and whose breadth, BC, is 3 ft. If we draw lines parallel to AB, 1 ft. apart, and lines parallel to BC, 1 ft. apart, the rectangle will be divided into squares, each of which is a square foot. But there are three rows of squares, and four squares in each row. Hence, the number of square feet in the area of the rectangle is 3 × 4.

154. Since, Length × Breadth = Area, it follows that, Length = Area ÷ Breadth, and, Breadth = Area ÷ Length.

If, then, we know any two of the quantities, length, breadth, area, we can find the remaining one.

Example 1. A plot of ground containing 1 acre is 44 yd. wide. What is its length ?

Since 4840 square yd. = 1 acre, the required length is

$$\frac{4840}{44}\text{ yd.} = \underline{110\text{ yd. } \textit{Ans.}}$$

Example 2. It costs £5 10s. 3d. to carpet the floor of a room 21 ft. long with carpet at 3s. a square yard. What is the breadth of the room ?

Here, the number of square yards in the floor is equal to the number of times 3s. is contained in £5 10s. 3d.

We must then be careful to divide the number of square *yards* in the floor by the number of *yards* in the length of the room, and not by the number of *feet*.

Hence,

$$\text{Area of floor} = \frac{\text{£5 10s. 3d.}}{\text{3s.}}\text{ square yd.}$$

$$= \frac{110\frac{1}{4}}{3}\text{ square yd.}$$

$$\text{Length of floor} = 21\text{ ft.} = 7\text{ yd.}$$

$$\therefore\ \text{Breadth of floor} = \frac{110\frac{1}{4}}{3\times 7}\text{ yd.} = \frac{21}{4}\text{ yd.}$$

$$= 5\tfrac{1}{4}\text{ yd.} = \underline{15\text{ ft. } 9\text{ in. } \textit{Ans.}}$$

Answers to Arithmetic

EXAMPLES 17

1. $4\frac{3}{4} : 380 :: £102$: Reqd. Amnt. Hence, amount to be invested

$$= £\frac{102 \times 380}{4\frac{3}{4}} = £8160\ \textit{Ans.}$$

2. His income from Consols = $94 \times £2\frac{1}{2}$ = £235. Therefore, income from 4 per cents. = £235 + £5 = £240. Amount obtained from sale of Consols = 94 × £90 = £8460. But, £240 income from 4 per cents. requires £(240 × 100 ÷ 4) stock = £6000 stock. Hence £6000 stock costs £8460. Therefore £100 stock costs £8460 ÷ 60 = £141 *Ans.*

3. Income from £5775 in the 3 per cents. = $57\frac{3}{4} \times £3 = £173\frac{1}{4}$. (The *price* of the stock, £99, does not affect the question.) Price of the $3\frac{1}{2}$ per cents. = $115\frac{3}{8} + \frac{1}{8} = 115\frac{1}{2}$. Therefore, since $115\frac{1}{2}$ must be invested to produce $£3\frac{1}{2}$ income, the amount which must be invested to produce $£173\frac{1}{4}$ is $£\frac{173\frac{1}{4} \times 115\frac{1}{2}}{3\frac{1}{2}}$ = £5717 5s. *Ans.*

4. Net income from each £100 stock = £5 − 5s. = $£4\frac{3}{4}$. To obtain an income of $£3\frac{3}{4}$ he has to invest £100. The price of the stock is the amount he has to invest to obtain an income of $£4\frac{3}{4}$. Hence, $3\frac{3}{4} : 4\frac{3}{4} :: £100$: Required price.

$$\text{Therefore, price} = \frac{100 \times 4\frac{3}{4}}{3\frac{3}{4}} = 126\tfrac{2}{3}\ \textit{Ans.}$$

5. L.C.M. of $3\frac{3}{4}$ and $4\frac{1}{2}$, *i.e.*, of $\frac{15}{4}$ and $\frac{18}{4}$, is $\frac{90}{4}$. Now, $\frac{90}{4} = 6 \times 3\frac{3}{4}$, or $5 \times 4\frac{1}{2}$. Thus, £600 stock in $3\frac{3}{4}$ per cents. produces the same income as £500 stock in $4\frac{1}{2}$ per cents. But £600 of first costs 6 × £90 = £540. Therefore £500 of second stock costs £540, so that price of stock = £540 ÷ 5 = £108 *Ans.*

6. L.C.M. of 90 and 98 = 4410. The income from £4410 invested in $3\frac{1}{2}$ per cents. at 98 $= £\frac{4410 \times 3\frac{1}{2}}{98} = £45 \times 3\frac{1}{2} = £157\frac{1}{2}$. Similarly, we find that the income from £4410 invested in 3 per cents. at 90 = £3 × 49 = £147. Thus, if the sum invested had been £4410, the income is $£10\frac{1}{2}$ greater in the first case than in the second. If, then, the income is £15 greater, the amount invested is $£\frac{4410 \times 15}{10\frac{1}{2}}$ = £6300 *Ans.*

7. The change in income is that due to investing £4131 in $5\frac{1}{4}$ per cents. at 119 instead of in $3\frac{1}{2}$ per cents. at 102. The income in the first of these cases is $£\frac{4131 \times 5\frac{1}{4}}{119} = £182\frac{1}{4}$. In the second case it is $£\frac{4131 \times 3\frac{1}{2}}{102} = £141\frac{3}{4}$. Hence he increases his total income by $£182\frac{1}{4} - £141\frac{3}{4}$ = £40 10s. *Ans.*

8. His income = 25 × £3 = £75. If all his money was invested in the $3\frac{1}{4}$ per cents., his income would be $£\frac{2500 \times 3\frac{1}{4}}{103\frac{1}{8}} = £78\frac{26}{33}$. This is $£3\frac{26}{33}$ greater than his actual income. Next, the L.C.M. of $£103\frac{1}{8}$ and £140 is found to be £4340. This sum, invested in $3\frac{1}{4}$ per cents. gives an income of $42 \times £3\frac{1}{4} = £136\frac{1}{2}$. The same sum invested in 4 per cents. gives 31 × £4 = £124. Thus, by investing £4340 in 4 per cents. instead of $3\frac{1}{4}$ per cents., the income would be reduced by $£12\frac{1}{2}$. We have to find how much must be invested in 4 per cents. to reduce the income by $£3\frac{26}{33}$. Thus, $12\frac{1}{2} : 3\frac{26}{33} :: £4340$: Required amount.

$$\therefore\ \text{Required amount} = £\frac{4340 \times 225 \times 2}{62 \times 25} = £1260.$$

Hence, £1260 is invested in 4 per cents. at 140, giving £900 stock ; and the remaining £1240 is invested in $3\frac{1}{4}$ per cents. at $103\frac{1}{8}$, giving £1200 stock. The answer is, therefore, £900 of 4 per cents. and £1200 of $3\frac{1}{4}$ per cents.

Continued

hydrochloric acid and the dioxide of manganese. What happens is that the oxygen of the latter turns out the chlorine from the hydrochloric acid, some of the chlorine combining with the manganese and some going free. The following equation represents the action:

$$MnO_2 + 4\,HCl = MnCl_2 + 2\,H_2O + Cl_2.$$

Like fluorine, though in less degree, this element is chemically very energetic, and in its undiluted state is scarcely less dangerous to work with. Pressure and cold readily convert it into a yellow liquid or solid. Also, like fluorine, it has great affinities for hydrogen, and will actually take this element—with which it forms hydrochloric acid (HCl)—not only from organic compounds which contain it, but also from its extremely powerful combination with oxygen to form water. Thus, while chlorine is soluble in water, it very readily decomposes the solvent, keeping the hydrogen and displacing the oxygen. This oxygen, at the moment of displacing, is *nascent*, and has the properties of any nascent element, as we showed when discussing peroxide of hydrogen. Hence, chlorine is, though so indirectly, one of the most powerful of all oxidising agents in virtue of its power of liberating nascent oxygen from water and other substances. This property of chlorine is chiefly used in order to bleach various materials, which it does by thus oxidising and altering the colouring matters that they may contain. The explanation we have given of the oxidising properties of chlorine will enable the reader to understand why the dry gas has no such properties. Chlorine is inimical to every form of life, and is thus probably the most certain and searching of all known disinfectants. This property also doubtless depends upon its oxidising action. Nevertheless, chlorine, when combined with other elements, has very different relations to living matter, for certain chlorides—especially sodium chloride, or common salt (NaCl)—are important constituents of the food of practically every living thing.

Bromine. As we advance in the series of the halogens, we pass from bodies which are gaseous at ordinary temperatures to one which is a liquid at those temperatures, and finally to one which is solid. *Bromine*, the third member of the series, is a liquid (with a deep red colour), that readily evaporates, producing a gas which has a disagreeable smell (Greek—*bromos*, a stink). In general, its properties closely resemble those of the previous members of the series. It occurs in nature mainly in the form of bromides, many of which are of importance in medicine, in photography, and for other purposes.

Iodine. *Iodine* is a dark crystalline solid at ordinary temperatures, but readily evaporates, forming a violet coloured gas. It is much less soluble in water than its predecessors; the vapour is very irritant, and has a similar action on the lungs and air passages to that exerted by the other halogens. While chlorine is of great use in medicine, indirectly, in virtue of its extremely marked antiseptic properties, iodine is used in medicine directly, occasionally internally and very frequently externally. It is still more valuable in the form of its salts, especially the iodides, such as the iodide of potassium (KI), which is obviously a salt derived from the hydriodic acid, previously mentioned.

Iodine and Living Tissues. When iodine, in its elemental form, is brought into contact with living tissues it exercises very marked actions. These are best illustrated by a consideration of what happens when a not too strong solution of iodine is painted on the skin. Doubtless the element undergoes rapid combination with certain of the tissues of the skin. In one form or other, it is certainly capable of being absorbed, and of exerting marked actions upon tissues lying at a considerable depth beneath the surface of the skin—almost as much so as if elemental iodine had been applied directly to them. In the language of medicine, elemental iodine and some of its compounds are said to act as *alteratives*, the reason being that they seem to produce very marked changes in the behaviour of various tissues. These changes are often so profound and extensive as to be quite out of proportion, it would appear, to the relatively small amount of substance that produces them. Hence it seems probable that the action of such a substance as iodine may be comparable in some small measure to the behaviour of oxide of barium, which is used, as we recently saw, in the commercial process for the obtaining of oxygen.

Mysterious Power of Iodine. We have seen how chlorine acts as an oxidising agent, and it seems probable that iodine, whether in its elemental form or as an iodide, must have the power of transferring oxygen from place to place, or acting as a so-called oxygen carrier, being thus able, even in very small quantities, to do a very large amount of work, just like the oxide of barium, which helps itself to an extra supply of oxygen, disposes of it, and thus is able to repeat the process indefinitely. Of course, in the example we have quoted, the conditions of temperature and pressure are altered by an agency from without; but it is quite conceivable that there may be a similar automatic mechanism in the body which enables iodine to act as it does.

The further and final stage in the illustration of the sort of process we are describing is furnished by the *ferments*, that extraordinary group of substances, the property of which is that, by their mere presence, and without undergoing any change in themselves, they are able to cause the most marked chemical changes in other substances with which they are in contact. We are far from supposing that the above sentences offer a chemical explanation of the properties of iodine, or of any other alterative substance; but it is, in effect, the explanation which is advanced by one of the very greatest students of the chemical interactions between such substances as iodine and the living body—Professor Binz, of Bonn. It was not necesssary to refer to the method by which bromine may be obtained in its elemental form, since elemental bromine is of small utility, and since the process is essentially the same as that by which iodine is prepared. It was in the *substance called kelp, variously defined as sea-weed, or the ash of the seaweed, that iodine* was first discovered. The plant obtains it from the sea-water in which it lives, and obtains bromine in like manner. When the ash is *distilled with sulphuric acid and the now familiar dioxide of manganese, first the iodine* comes away, and then the bromine.

The Halogens and the Periodic Law. It is now hardly necessary to say that the whole series of halogens offers excellent confirmation of the periodic law of Mendeleeff, and that the chemical properties of these bodies, the conditions under which their compounds are formed, and their reactions generally, correspond in an extremely significant degree to the properties which might have been assumed for them by anyone who had nothing but the periodic law from which to argue. For instance, the atomic weight, the boiling point, the specific gravity, the temperature at which combination occurs with hydrogen, and a whole series of further properties, follow definite gradations in the case of these four elements. It is not improbable that this group will afford the most valuable help to the chemist and the physicist in their most recent and most important enterprise, which is the attempt to infer, from what they know of the various elements, the details of the atomic structure or architecture of those elements and the exact manner in which, for instance, the atom of chlorine differs from, yet resembles, the atom of fluorine, while the difference between the two must consist in some detail of structure which is perhaps repeated or doubled in order to get the further differences represented by the bromine atom, and lastly by the atom of iodine.

Peculiar Properties of Platinum. Platinum is a very rare and precious metallic element. Chemically, it may be grouped with another metal, *palladium*, and with certain others of very small importance in themselves, such as *osmium*, *rhodium*, *ruthenium*, *iridium*. These elements occur in nature uncombined, and in the metallic state, usually in the form of tiny grains in the sands of certain rivers. Platinum is thus found in California and South America, Australia, and the Ural Mountains. The processes by which these metals are obtained in any quantity in the pure state are extremely difficult and complicated. When at last metallic platinum is obtained in a form that can be manipulated, it is found to be a white, lustrous, silvery metal of a very great weight (its atomic weight is nearly 195), and having a number of very important physical properties. For instance, it is extremely difficult to fuse or melt, requiring no less than the temperature produced by the immediate union of oxygen and hydrogen in the oxy-hydrogen blowpipe. Readers of the course on PHYSICS will understand what is meant when we say that this rare metal has extreme tenacity, is very malleable, and very ductile. It does not oxidise even when heated in pure oxygen; strong mineral acids do not affect it, nor is it acted upon by moist air. For all these reasons, platinum is very extensively used in various chemical operations, *especially when it is required* to deal with *powerfully corrosive liquids, such as sulphuric acid and hydrofluoric acid, or when* any great heat is required. The metal can be cast and forged, and can also be welded; furthermore, it expands under the influence of heat only very slightly, so that when it is fused through glass, as, for instance, in the ordinary incandescent electric lamp, alterations in temperature cause the platinum and the glass to expand or contract proportionately, so that the glass is not cracked by the expanding metal when the lamp is lit.

Absorption of Gases by Platinum. In a previous chapter we made some reference to the remarkable property possessed by some substances of absorbing gases within them. Charcoal is a conspicuous and familiar instance of a substance which has this power. It is to be remembered also that there is more than a merely physical absorption of the gas, since in the case of oxygen the result of this absorption is to increase its chemical activity. Hence it seems probable that the molecular arrangement of the gas is disturbed. Now, platinum, when finely divided and forming the black powder *platinum black*, has this property of condensing gases in it to an extraordinary degree, being able to absorb, for instance, some hundreds of times its own volume of oxygen.

Another form of platinum, called *spongy platinum*, and also the platinum black of which we have already spoken, are able to induce chemical actions, such, for instance, as the direct union of oxygen and hydrogen at ordinary temperatures—which is explicable if we accept the view that the condensation of such gases within their pores is more than a merely physical act, and implies a change in the molecular constitution of the gases, so that they become practically as chemically active as if they were *nascent*. Very probably, indeed, they *are* nascent, in the sense that a large number of their molecules are broken up, so that unpartnered atoms of oxygen and hydrogen are wandering about, being thus more ready to effect chemical combinations with foreign atoms than if they went about with each other in pairs, as they do in the molecules of these gases in ordinary conditions.

The Last Group of Metals. Finally, we must discuss a very important group of metallic elements consisting of *copper*, *silver*, *gold*, and *mercury*. We may take these elements together, even although they do not exactly fall into a group in the table of the periodic law published by Mendeleeff in 1904. When we were discussing the atmosphere, we saw that the new group of gases discovered in the air by Lord Rayleigh and Sir William Ramsay—helium (already known elsewhere), neon, argon, krypton, xenon—must now be regarded as the zero group of the elements. Not one of these gases has any combining power at all, so far as can be made out. Group one of the elements has already been partly discussed. Its members have combining power, each atom of any typical one of them having, so to speak, one arm, and being therefore called monovalent. The members of this group, in the order of their atomic weight, are hydrogen, lithium, sodium, potassium, copper, rubidium, silver, cæsium, and gold, and the reader will notice that the lighter members of the groups have already been considered. Ignoring the very unimportant elements, rubidium and cæsium, we are therefore left with copper, silver, and gold. According to Mendeleeff, mercury, which has so many remarkable peculiarities, belongs not really to this group at all, but to group two. We are bound to note this fact; yet we may conveniently adhere to the long-established arrangement and discuss mercury together with the other three elements we have named.

What Makes Copper Valuable. All these four elements are found in the elemental state in nature. But the first of them, copper, more commonly occurs in combination either with oxygen or with sulphur. It is very readily obtained from its oxide by the now familiar employment of carbon, in the form of charcoal or coke, which takes the oxygen to itself and leaves metallic copper behind. Or copper may be displaced from the familiar salt known as copper sulphate ($CuSO_4$) by means of iron, which forms sulphate of iron ($FeSo_4$), the copper being precipitated; and a third method of obtaining metallic copper consists in an interaction between the sulphide and the oxide. The sulphur and oxygen of these respectively, combine to form the gas sulphurous anhydride, or sulphur dioxide (SO_2), metallic copper being left behind.

This extremely valuable metal has a distinctive colour, an atomic weight of rather more than 63, but a very small degree of hardness. It is very malleable, tenacious, and ductile [see PHYSICS], is fusible—that is to say, melts—at a red heat, and is an excellent conductor both of heat and electricity. In this last respect, as in the others, it resembles silver and gold, but being much cheaper than either of these metals, it is naturally preferred to them as a material for wires to convey electric currents. In electric conductivity copper is second only to silver; but it must be extremely pure copper, its electric conductivity being very greatly reduced by even very small traces of foreign substances. Hence, the methods of obtaining metallic copper above mentioned have to be abandoned and electrolysis substituted when copper is required for electrical purposes.

Bronze. Amidst all these valuable physical properties of copper it is to be noted that there is one—*viz.*, its relative softness—which interferes with its utility for many purposes. But when copper forms an alloy with tin there is obtained the substance called bronze, which is very much harder. Bronze has been known since very early times; and the student of what we are now learning to call pre-history speaks, as we saw in the first chapter of this course, of the Bronze Age, which succeeded the Stone Age, and marked a great advance in civilisation, largely dependent upon the newly acquired knowledge of manipulating bronze, and was in its own turn succeeded by the Iron Age. Thus, this element, copper, has its own special interest for the philosophic student of the means by which man gradually emerged from primitive savagery. Here we may also note that in recent years it has been discovered that the addition of a small quantity of phosphorus to bronze, producing the alloy called *phosphor bronze*, greatly increases its hardness and gives it a new value as a material for cog-wheels and other parts of machines where great hardness is desirable. It is the opinion of Lord Avebury—perhaps better known as Sir John Lubbock—that the use of copper was not introduced into Europe at all until it had first been discovered somewhere in the East that a much more valuable substance could be produced by the addition of a small quantity of tin to it—that is to say, by the making of the alloy called bronze. The alloys of copper now in use are very numerous—about 70 per cent. of copper and 30 per cent. of zinc forming brass—whilst there are various modifications of bronze besides phosphor bronze, the aluminium bronzes and German or nickel silver, the alloy of copper and zinc, to which reference has already been made.

Copper and the Human Body. Minute traces of this element are not infrequently found in the human body, yet it is certainly not to be regarded as a desirable constituent of the body, but rather as a more or less undesirable foreign substance which has gained access to it by means of the food. Salts of this metal are often used in order to make more vivid the green colour of vegetables, such as bottled peas, and the question arises whether the use of copper for this purpose is at all justifiable. There is good reason to believe that if the quantity employed is very small—though quite large enough for the purpose—it has no injurious action upon the body, copper being exceedingly difficult to absorb, so that even if moderate quantities are frequently swallowed no harm is done. So far as acute poisoning from copper is concerned, the risks are also very much less than is commonly supposed, and the smallness of the risk of chronic copper poisoning may be estimated from the fact that there is no proof of this having occurred even amongst workmen engaged in the manufacture of *verdigris*, which is the acetate of copper.

Silver. This precious and familiar element occurs, as we have already stated, in its elemental form in nature, and is also frequently found in combination with sulphur, the sulphide of silver being known as *silver glance*. It also is found in union with mercury in various parts of the world. We have purposely avoided the use of the word combination, which would beg the question whether this body is really to be regarded as a compound or as a mixture. Its composition varies, and we know that the composition of a true compound is absolutely invariable. But on the other hand this *amalgam*, as it is called, is crystalline, and the relations of the elements in it must probably be regarded as more than a mere mixture.

The appearance of the metal and its capacity for taking a high lustre are familiar; like copper, it is very ductile, malleable, and a good conductor of heat and electricity. Also like copper—and the same applies to gold—it is not oxidised by the air, no matter whether moisture be present or not. Copper, however, can be oxidised at a red heat, but silver only at a much higher temperature and under great pressure, while gold cannot be made to unite with oxygen directly at all. The marked stability of these metals led them to be called, in former days, the "noble metals"; they vary in their nobility, however, as we have already seen, and even at ordinary temperatures silver loses its lustre and its purity in the presence of compounds of sulphur, such as the gas called sulphuretted hydrogen (H_2S), or the gas we have already mentioned, sulphur dioxide (SO_2). This change is due to a formation of a thin film of the black sulphide of silver. A curious illustration of this property of silver is furnished by the consequences not infrequently observed when considerable doses of sulphur are being given medicinally to people who wear silver ornaments, such as bangles, next to the skin. In such cases the patient is sometimes puzzled to know why the bangle cannot be kept clean; its blackening is due to the fact that some of the sulphur given to the patient is passed through the skin, in various forms, which attack the surface of the silver and cause the formation of a thin layer of the black sulphide.

Readers of the course on PHYSICS are now familiar with the "three states of matter," and will not be surprised to hear that at sufficiently high temperatures silver is found in the form of a bluish gas. This fact is almost as surprising to some people as is the fact that air may be obtained in the form of a liquid that looks like water, or a solid that looks like ice.

The "Nobility" of Gold. This more or less familiar element is closely allied in its properties to those we have previously discussed. It is pre-eminently the noble metal, remaining unchanged in the presence of even moist air, and, indeed, declining to undergo direct oxidation under any conditions whatever; it is very ductile, tenacious, and malleable. Copper, silver, and gold, indeed, are all so malleable that they can be beaten into films that will transmit light, and the thinness to which gold-leaf may be reduced is almost incredible. A reference to the table in an early lesson will remind the reader of the very great weight of gold. Its atomic weight is rather more than 197. Though gold is so scarce, has such a fine lustre, is so "noble," and is the only yellow metallic element, it is by no means the dearest of the elements. Compared with radium, for instance, it is "dirt cheap." It is even more resistant to chemical action than the other members of this group. The powerful acids, for instance, such as hydrochloric, nitric, and sulphuric acids, will each dissolve copper, but the only means by which gold may be made to yield to them is by the combined action of nitric and hydrochloric acid. The mixture of these two acids, being able to dissolve gold, has been known for many centuries as *aqua regia*, which we may translate as the regal fluid. The compound which is formed when gold is thus dissolved is called auric chloride, and has the formula $AuCl_3$.

Gold occurs in nature chiefly in its elemental state; its distribution is very wide, though the total quantity is so small. For instance, it occurs in minute quantities in iron pyrites (FeS_2), and in galena, the sulphide of lead (PbS), of which we have already made the acquaintance. Extremely minute traces are found in sea-water.

The Possible Making of Gold. We are all familiar with the fact that the alchemists spent long years in seeking the philosopher's stone which would turn all the base metals into gold. Probably every reader in his time has had his laugh at these vain efforts; and certainly we may agree that there is no such philosopher's stone. But we are now coming to see that the alchemists were not so far wrong after all. They believed that under the differences which the elements display there must be an essential similarity, and we now know that they were right. It is especially that extraordinary element radium, of which we shall have much to say later on, that has taught us to regard the transmutation of the elements not merely as possible, but as, in at least two known cases, an observed and proven fact. So far, all the evidence of such changes that has been established is concerned with what we may call downward changes—that is to say, changes from heavier and more complex elements towards lighter and simpler ones. On the other hand, there is no theoretical impossibility in the performance of the reverse process, such as, for instance, the building up of heavy and complex-atomed elements such as gold from simpler ones. There is, indeed, every indication that chemistry is now upon the brink of quite incalculable possibilities; it was at these that the discoverer of radium, M. Curie, was hinting when he recently came over from Paris to receive a gold medal from the Royal Society. In acknowledging the honour that had been paid him he jokingly remarked that he would do his best to see whether he could not turn the medal into radium. Ten years ago such a remark would have been a pointless absurdity, but now it is very significant. The work of Madame Curie and others has shown us that the atomic weight of radium is heavier than that of gold; and if the reader remembers what we have said as to the comparative probability of building up heavy elements from light ones, and vice versâ, he will see that if gold or any other element, often of far more intrinsic value than gold, is to be produced by transmutation, the element to be transmuted is more likely to be one that is more complex and heavier than gold. It will not be long before phrases like "analysis of the elements" and "synthesis of the elements" make their appearance in text-books. We are on the brink of the *New Alchemy*.

Continued

VARIETIES OF CONSTRUCTION

Earthwork. Mixing and Laying Concrete. Ferro-concrete. Brickwork and Masonry. Timber and Piling. Ironwork

Group 11

CIVIL ENGINEERING

10

Continued from page 1240

By Professor HENRY ADAMS

IT will be useful, before studying the details of any one class of construction, to obtain a general idea of the various materials employed and the modes of using them.

Earthwork. Excluding the use of earthwork in military defences, earthwork may be said to be used only in embankments in one form or another, and of these, railway embankments form the largest proportion. In designing railways, endeavour is made to obtain the minimum gradients, and at the same time to arrange the levels so that the amount of material required to form embankments may equal the amount excavated in forming the cuttings. If surplus material be excavated spoil banks have to be formed to get rid of it. These are filled up to rail level, and may sometimes be utilised in forming sidings, but often they are so much waste ; while if there be a deficiency of material from the cuttings it is necessary to obtain a supply from elsewhere at an increased cost. The side slopes will depend upon the nature of the material. In solid rock the sides may be vertical ; in chalk, which is soft rock, they may be nearly vertical ; in gravel and compact earth they may be 1 to 1, or 1½ to 1—that is, 1½ horizontal to 1 vertical ; and in clay they may need to be as flat as 2½ to 1, or 3 to 1. A general average may be taken for the side slopes of 1½ to 1, both in cutting and embankment. As a railway embankment starts from a cutting with no vertical height and increases in depth until the centre of the valley is reached, the most convenient method is to tip the material forward, over the requisite width. For a single line of railway two tips in the width may be sufficient, but for a double line of rails with a surface width of, say, 26 ft., four tips will be necessary, otherwise the material will roll from the centre outwards and the embankment will be liable to slips.

A longitudinal section through the embankment should show the layers in lines inclined forward from the cutting [1], while a cross-section should show the layers in lines [2]. Wherever a stream crosses the line at the bottom of a valley, or on the side of a hill, a culvert has to be formed to allow of the passage of the water during and after completion. This may be merely a wooden box-like trough, or may be like a miniature tunnel in brickwork or masonry. In either case it has to be formed before the embankment is carried over it, and, to prevent pushing it over, it is necessary to tip on both sides of it until it is fairly covered.

Settling of Earthwork. The excavated material occupies more space than it did before it was disturbed, the increase in bulk averaging as follows: Gravel, 7 per cent. ; gravel and sand mixed, 8 per cent. ; clayey earths, 10 per cent. ; light, loamy soils, 12 per cent ; soft rock, 30 per cent. ; hard rock, 40 per cent. After the embankment is made it naturally consolidates by the action of the weather and the efflux of time: Generally, with the ordinary materials, 3 or 4 in. additional height for every 6 ft. in depth is allowed for settlement, otherwise the embankment must be made up to keep it to "grade level." Rankine says—"Embankments settle after their first formation . . . . . seldom less than one twelfth and seldom more than one-fifth of the original height." But this greatly depends upon the amount of rainfall during the construction: dry lumpy soil leaves most vacant spaces. The ballast to form the road is generally flint gravel, slag, broken stone, or burnt clay, to obtain better resistance to the action of the weather.

Earth Dams. These are embankments formed at the mouth of a valley to shut in the water in forming an impounding reservoir. The general section is as shown in 3, where the dotted lines indicate the slope of the layers in the formation of the embankment. The essential feature is an impervious wall of puddled clay in the centre to prevent the percolation of water from one side to the other, the smallest leak being extremely dangerous. Selected material is placed next and almost any kind is used outside to give the mass necessary for stability. The puddled clay must be sufficiently protected on the top to avoid any possibility of drying and consequent cracking. The outer and inner slopes depend somewhat on the natural slope due to the material, but they are usually 3 to 1 on the inner or water side, and 2 to 1 on the outer side.

At the back of any retaining wall the earth must be benched out as in **4**, and the material that is filled in must be rammed in layers inclined from the wall. It will thus be seen that in every case particular care must be taken to minimise the tendency to slip.

Concrete. Concrete is made in two main varieties—lime concrete and Portland cement concrete. Lime concrete is the cheaper and is used only in foundations, but is of no more utility than a similar amount of gravel, and in damp situations may even be worse. Wherever it is necessary to use any concrete, Portland cement should be employed, but an exception may be made in favour of Lias lime concrete where this is readily procurable. Cement concrete consists of 1 part of Portland cement, by measure, to 1 or 2 parts of sand as the matrix, and 4 to 8 parts of broken brick or stone, flint pebbles, clinker, coke breeze or other hard material as the aggregate, varying in size according to the purpose. The theory of the mixture is that the spaces between the larger pieces of the aggregate should be entirely filled by the smaller pieces, that the spaces still existing should be filled by the sand, and that the whole of these materials, including the sand, should be thoroughly coated with the cement, and form a solid mass which shall offer great resistance to compression. Other things being equal, the resistance will vary with the ratio of cement to aggregate. For suspended concrete floors and for thin concrete walls, a mixture of 1 to 4 is used, and the largest pieces of the aggregate must not exceed 1 in. in any dimension.

Complete cottages and blocks of industrial dwellings have been built entirely of concrete, but they are not popular. It is difficult to prevent the walls from cracking, the rooms are said to be cold and cheerless, to echo considerably, and to have moisture deposited on their surfaces, due to their non-absorbent character, upon a sudden rise of temperature. For heavy retaining walls [5] and foundations the mixture may vary from 1 to 6 up to 1 to 8, according to circumstances, and the largest pieces should pass a 2-inch ring gauge. It is most important that there should be no clay or earthy matter in the mixture as this would cause a thin coating of mud over the sand and aggregate, and prevent the adhesion of the cement; this is what is meant by sharp sand. All sand has been formed by attrition in water, and the grains are therefore more or less rounded, but when there is an absence of loamy particles it feels gritty to the touch when rubbed between the fingers, and this constitutes what is called sharpness.

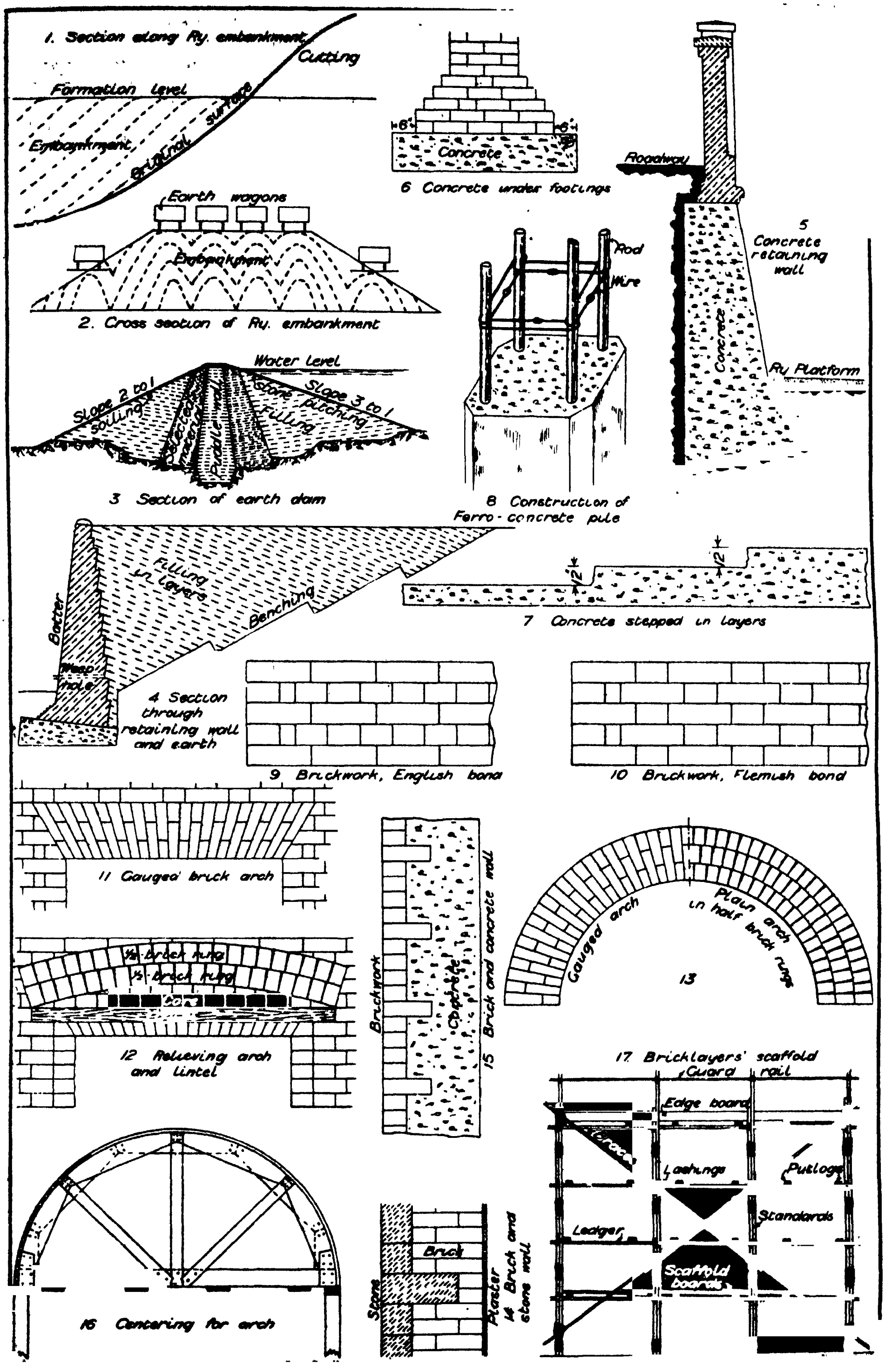
Mixing and Laying. The materials should be mixed on a wooden platform so that the shovels may be used freely without risk of incorporating earthy particles in the mass. They should be thoroughly mixed dry, and then again be well mixed while being watered through a rose, the object being to moisten every particle without washing away any of the cement. As setting takes place very rapidly, not more than half a cubic yard should be mixed at one time and it should be all deposited in place within one hour of mixing. Any disturbance after it has begun to set interferes with the crystallisation and reduces the strength.

It was formerly customary to specify that concrete should be tipped from a height of 10 feet so as to consolidate it; but it is now always deposited as carefully as possible without a drop and then gently rammed with iron beaters; the water should be only sufficient to float in a thin film on the surface. Under the footings of a wall it is generally 9 to 18 in. thick and projects 6 to 9 in. on each side, in order to spread the pressure over a sufficient width of soil to avoid settlement. The minimum amount of concrete under footings is shown in 6. In the formation of walls it is necessary to confine the material between boarding, the width of the space left fixing the thickness of the wall. To prevent shrinkage, and consequent cracking, the cement should contain no appreciable quantity of free lime, and it should be thoroughly air slaked before use. Machinery is usually employed when large quantities are required, many different forms of steam-driven concrete mixers being in use. Concrete in mass should be deposited in layers not exceeding 12 in. thick, as in 7, but the work may go on over a large area and even be completed at one part before another is started if it has long steps of 12 in. each.

Ferro-concrete. Ferro-concrete is the name given to a combination of concrete and steel in the form of rods or bars, the concrete taking the compression and the steel the tension. This allows a great reduction to be made in the mass and it is now being largely applied to all kinds of construction, with various modifications in detail. It is, however, necessary to use the very best material and to employ only skilled labour, in order to realise the strength contemplated by the designer. Fig. 8 shows a ferro-concrete pile on the Hennebique system and a similar construction is used for ferro-concrete stanchions. Floors have the steel rods in the lower part of the thickness and carried up over the bearings to resist shear.

Artificial Stone. Artificial stone is a kind of concrete made of Portland cement and granite chippings pressed in zinc-lined moulds to form paving flags, lintels, sills, thresholds, copings, window and door dressings, and moulded ornaments. As soon as the articles can be handled they are removed from the moulds, put in tanks and covered with a solution of silicate of soda for about fourteen days, during which time a chemical change takes place and the resulting material is very hard and non-absorbent, wearing evenly and very slowly. One variety is made from pulverised York stone and put under great pressure. Another is made from sand and chalk lime mixed dry and put into a perforated steel box with a copper lining; a vacuum is created in the box, and boiling water introduced under pressure to slake the lime. Then superheated steam is forced in to complete the slaking, and the whole process is finished in about eight hours.

Concrete Blocks. Concrete blocks may be looked upon as a rough kind of artificial stone. They are formed of ordinary concrete placed in wooden moulds, and are often used in the formation of river walls and sea walls, being used like large blocks of stone. For exposed positions the blocks are larger, and either cramped together or made with grooves, to be filled with pebbles and cement after placing them together. For breakwaters the concrete blocks may reach 100 tons each, or more, in order that they may not be disturbed by the shock of the waves. When the concrete is deposited in mass under water, it is called *béton*; it is then usually rich in cement to allow of some being washed out, and is shot down a trunk, or lowered in skips with movable bottoms, to prevent as much as possible from being carried away.



1. Section along Ry. embankment

2. Cross section of Ry. embankment

3 Section of earth dam

4 Section through retaining wall and earth

5 Concrete retaining wall

6 Concrete under footings

7 Concrete stepped in layers

8 Construction of Ferro-concrete pile

9 Brickwork, English bond

10 Brickwork, Flemish bond

11 Gauged brick arch

12 Relieving arch and lintel

13

14 Brick and stone wall

15 Brick and concrete wall

16 Centering for arch

17 Bricklayers' scaffold

EARTH, CONCRETE, AND BRICKWORK IN CONSTRUCTION

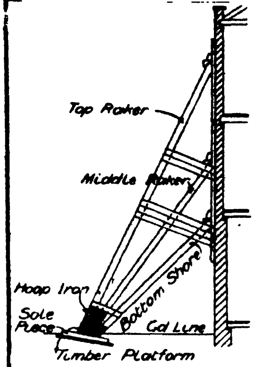
Brickwork. Bricks are small blocks of baked clay, of slightly different sizes in different districts. In London and the South of England they are generally smaller than elsewhere, but including the mortar joints they may be considered as 9 in. long by 4½ in. wide by 3 in. thick. In the Midland and Northern districts the bricks themselves are mostly of the latter size, so that it is sometimes difficult to bond two varieties together. The approximate size has been settled naturally by what is convenient for the bricklayer to handle, and it is suitable for building up structures and openings of useful dimensions. Bricks are connected together by mortar composed of one part of grey stone lime to two parts of clean sharp sand, or, in more important work, by mortar composed of one part of Portland cement to three parts of sand. They are laid so as to break joint with each other and form a bond, or toothing, which strengthens the work and distributes the pressure over a wider area. English bond, as in **9**, is considered to be the strongest, and is used for warehouses and railway work where strength is of more importance than appearance; Flemish bond, as in **10**, is generally used for house building on account of its better appearance. There are several other forms of bond less frequently used.

Bricklaying. In the interior of all walls the bricks are laid as far as possible transversely, with joints running through from face to face, so that the distinctive names apply only to the face work. The base of a wall is always extended by footings, each projecting 2¼ in. on each side, until the bottom width is double the thickness of the wall. The height of any wall should not exceed 16 times its thickness, but generally the thickness is determined by the local bylaws. When openings are formed in walls they may be closed in at the top by lintels or straight beams of concrete, artificial stone, or natural stone, which are usually surmounted by an arch in order to relieve the lintel from pressure. These lintels seldom extend more than 4½ in. in from the face of the wall and gauged arches [**11**] are frequently substituted for them. The remaining thickness of the wall over the opening is generally carried by a relieving arch built in half-brick rings with a core below supported on rolled joists or fir lintels [**12**]. In the latter case the arch extends to each extremity of the timber, so that if it should decay or be burnt out only the core will fall and the brickwork above will remain, supported by the arch. When the opening may be curved on top a brick arch without a lintel is employed, the bricks being either gauged or laid in plain half-brick rings [**13**]. When the available space above the opening is insufficient for an arch, rolled steel joists are used, and they have the advantage of providing a suitable bearing for cross-joists, should such be required.

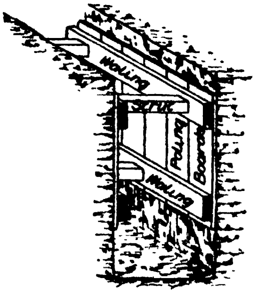
In gauged work the bricks are cut or rubbed so as to make true surfaces which only require thin joints, say ⅛ in. thick, while in ordinary brickwork the roughness and irregularity of the bricks necessitates a joint at least ¼ in. thick. Brick retaining walls are generally built with a battering face, as in **4**, to throw the centre of gravity well back, and the courses are then built with a slope backwards perpendicular to the direction of the face. The back of the wall may be straight and vertical, or may be stepped to increase the thickness towards the base. A thickness at base of one-fourth the height would be a light wall, and a thickness of one-third the height would be a fairly heavy wall. They are designed according to the pressure likely to be exerted against them by the supported earth, and this again is dependent upon the natural slope of the material, or the slope at which it would permanently remain if exposed to the weather and unsupported. Provision has to be made by weep holes for the escape of any water, which might otherwise tend to accumulate at the back and overturn the wall. Piers need to be very carefully bonded, as they very often have to carry heavy loads. Every joint in a course should be covered by a brick in the courses above and below, or, as it is technically described, no straight joints should occur in the interior of the work.

Masonry. Masonry was formerly divided into brick masonry and stone masonry, the term masonry referring to the building together of separate blocks. A change has been taking place during the last 50 years, and the term masonry now relates only to stone work. Rough stone, as picked up from the surface of the fields in stone districts, may be used without any preparation to form dry stone division walls to the fields, or they may be laid in mortar to form rubble work. The refuse stone from a quarry may be used in a similar way, forming flat-bedded rubble when the stone is laminated, or various forms of polygonal work, random work, or snecked work, when hammer dressed. Rough rubble work is strengthened by being brought up to level courses every two or three feet in height, so that a fresh start may be made at each new level. When each stone is roughly squared, the stability is greatly increased, while in random rubble the strength is practically limited to that of the mortar in which it is bedded. When the squared stone is of large size it is called *block-in-course work*, and this is the best kind of rubble. Some varieties of stone, such as Kentish rag, are so tough that they can be worked only by a hammer and used as rubble, but sandstone and those limestones that come under the designation of freestone can be truly dressed with a chisel to form large blocks of ashlar, and these, when built up, form the strongest kind of work, suitable for public buildings. When a stone is close-grained and can be worked with sharp arrises it is suitable for moulded work, and can then be used for window dressings and architectural work in general. There are many different ways of finishing the face and the edges, according to the nature of the stone and the taste of the architect.

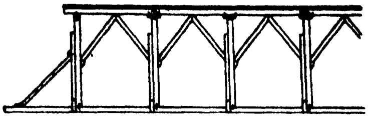
In the construction of lighthouses not only the hardest stone, such as granite, has to be used, but the blocks have to be very truly dressed and dovetailed together, with cramps between the



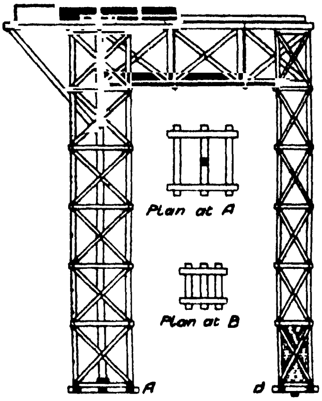
18 Raking shores



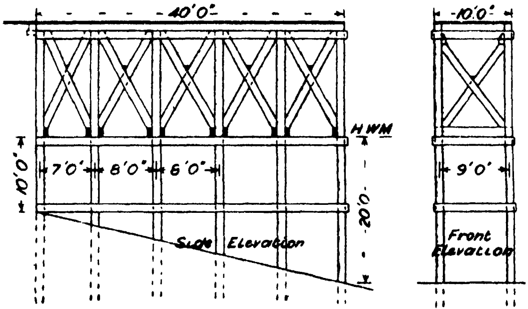
19 Timbering for trench



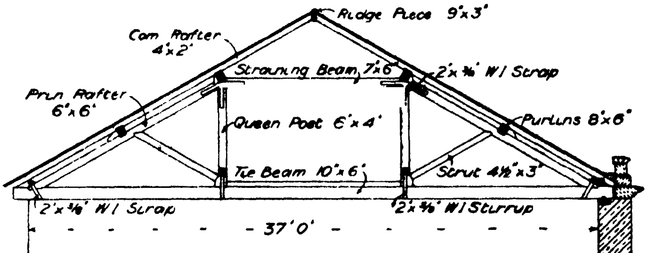
20. Gantry for traveller



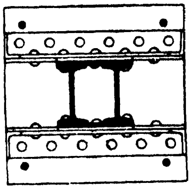
21 Derrick staging



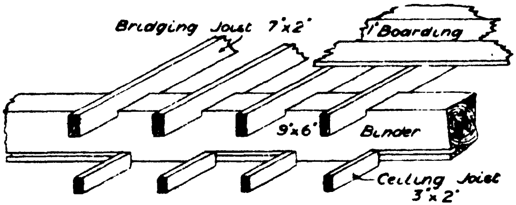
22 Timber jetty



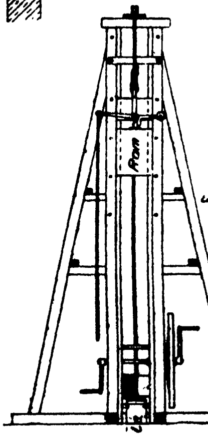
23 Queen post roof truss



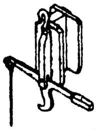
28 Base of riveted steel stanchion



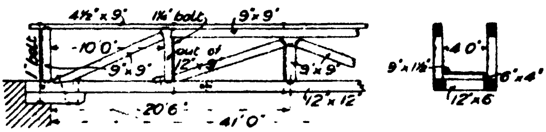
24 Naked flooring



26 Pile engine



27 Monkey used in pile driving



25 Timber bridge

USE OF TIMBER IN CONSTRUCTION

courses. Masonry dams for water reservoirs also require very careful dressing and bedding to ensure the greatest strength with the smallest quantity of material. With laminated stone it is necessary to place the blocks so that the natural bed is perpendicular to the pressure. The laminations will therefore be horizontal in a wall, and radial in an arch; but in an undercut cornice the laminations are vertical, running from front to back, to avoid the risk of pieces dropping off. Hard stone resists the action of the weather very considerably, but under the action of fire is far less resisting than common brickwork. Owing to the cost of stone in some districts walls are built of brickwork and only faced with stone, as shown in **14**. In these cases it is necessary to bond the two materials together by limiting the height of the stone to so many courses of brickwork, and building some stones further in; or cramps may be used to connect the two at short intervals. In a somewhat similar manner walls are sometimes built of concrete and faced with brickwork, as in **15**. Generally, the chief material used in building depends upon what is most readily obtained in the district.

Timber. Timber in constructive work is mostly used for temporary purposes, as for centering to support arches during construction [**16**], scaffolding [**17**], stagings, shoring, and struttings [**18**], supporting the sides of excavations [**19**], gantries [**20**], derrick stages [**21**], etc. In permanent work it is used for gantries in stone-yards, jetties [**22**], roofs [**23**], and floors [**24**]. Where timber is plentiful and other material is scarce, it is used for bridges [**25**], and for complete buildings. There are a few important principles to bear in mind, as laid down by Professor Rankine—*viz.*:

1. To cut the joints and arrange the fastenings so as to weaken the pieces of timber that they connect as little as possible.

2. To place each abutting surface in a joint as nearly as possible perpendicular to the pressure which it has to transmit.

3. To proportion the area of each surface to the pressure which it has to bear, so that the timber may be safe against injury under the heaviest load which occurs in practice, and to form and fit every pair of such surfaces accurately in order to distribute the stress uniformly.

4. To proportion the fastenings so that they may be of equal strength with the pieces which they connect.

5. To place the fastenings in each piece of timber so that there shall be sufficient resistance to the giving way of the joint by the fastenings shearing, or crushing their way through the timber.

To these may be added a sixth principle not less important than the foregoing—*viz.*: To select the simplest forms of joints, and to obtain the smallest possible number of abutments.

In framing structures, the chief point is to see that they are properly braced by diagonal struts to prevent racking movements caused by wind or other side pressures.

Timber piling is much used in riverside work. Whole timbers from 10 to 14 in. square are preferred for this work, pointed and shod with iron, and hooped at the top to prevent splitting while being driven. A ram, weighing from 5 to 30 cwt., is raised by a pile engine [**26**] and released by the use of a trip lever, or monkey [**27**], when it reaches the top, so as to give a heavy blow on the head of the pile, and this is repeated until the set or distance driven by the last blow does not exceed ¼ in. Piles, properly driven, will usually support a load of 1 ton per inch width of side in firm ground, or 5 tons per square foot of cross section in soft ground.

Iron. Iron is the generic term for three classes of material—wrought iron, mild steel, and cast iron. These differ in composition, chiefly in the proportion of carbon combined with the iron, but this trifling difference has a remarkable influence upon the properties of each. Wrought iron with ¼ per cent. of carbon is tough, fibrous, ductile, and can be forged and welded. Mild steel, with ½ to 1 per cent. of carbon, is tougher, more homogeneous in structure, somewhat ductile, and, with care, can be both forged and welded. Cast iron, with 2 to 5 per cent. of carbon, is crystalline, brittle, cannot be forged or welded, but may be cast in various shapes by melting and pouring into a mould. As may be gathered from the properties, wrought iron is used where the piece is required to resist tension, or cross strain, or where it has to be rolled or forged into shape, or welded to connect it with other pieces. Mild steel is used for similar purposes where greater strength is required. It is mostly found in the form of rolled joists, angles, bars, and plates, and used for the construction of girders, roofs, bridges, cranes, boilers, etc. Cast iron is very strong in compression, but weak in tension, and is therefore used where its particular properties render it specially useful, as for castings, brackets, machinery framings, columns, and stanchions. The latter, being subject to direct loading, are in simple compression, but when the ratio of length to least diameter exceeds about 26, cast iron shows a tendency to bend, and then wrought iron or mild steel are more appropriate.

Bolts and Rivets. These have been called the *stitches* by which ironwork is connected. The bolts being easily removable, may be likened to chain-stitch; and rivets, having to be cut out individually to remove them, are typical of the lock-stitch. Bolts are used for connecting cast-iron work, because the material will not stand the blows necessary in riveting. They are also used in wrought iron and steel work where connections have to be made on the ground during erection, to avoid the fire risks from having a rivet forge on an unfinished building, and to avoid the expense of engaging skilled men to put in a few field-rivets, as they are called. Rivets are specially used in the permanent connection of wrought iron and steel work; they bind the parts closely together, rendering the construction stiff and rigid, and permitting a proper distribution of stress through the various members. Fig. **28** shows the plan of base of a riveted steel staunchion.

Continued

LIME AND LIME BURNING

Limestone and Chalk. Chemical Composition. Types of Kilns. Lime Burning. Quicklime and Slaked Lime. Hydraulic Limes. Mortar

Continued from page 1285

By CLAYTON BEADLE and HENRY P. STEVENS

Chalk and Limestone. The raw material for the preparation of lime consists of a chemical substance known as calcium carbonate, which is found occurring naturally in large deposits as chalk, limestone, and in other forms.

To convert these substances into lime, they require to be strongly ignited, so that the carbon dioxide they contain may be driven off.

$$\frac{CaCO_3}{\text{Calcium carbonate}} = \frac{CaO}{\text{Quicklime}} + \frac{CO_2}{\text{Carbon dioxide}}$$

The process of preparing lime, generally known as "lime burning," is an extremely old one. Lime is the main constituent of mortar, and, as such, was used in building construction a thousand years ago or more.

To prepare pure lime some form of calcium carbonate is required, free from clay and earthy matters, and for laboratory use marble is a suitable substance; but for building purposes, where large quantities are required, marble is too compact a material and too costly.

Neither chalk nor limestone consists of pure calcium carbonate, but the natural rocks always contain small quantities of "silica" or "silicates," in the form of flint and other substances. Some account of silica and silicates will be found in the CHEMISTRY course. We may, however, state here that such substances as sand, flint, and rock crystal consist of silica, while clay is mostly made up of silicates.

Chalk Deposits. In the South of England there are two well-known chalk deposits. The upper, or white chalk is a very pure material, containing at most two or three per cent. of silicate of alumina and iron, while the grey, or lower chalk, which underlies the white chalk in the Thames estuary and the Medway district, is not so pure, and contains on an average 90 per cent. of carbonate of lime and 10 per cent. to 15 per cent. of clay substance. These clay matters are, of course, naturally incorporated with the chalk and cannot be removed. If less than 5 or 6 per cent. be present, a so-called "fat lime" is obtained, while with larger percentages of silicates the products are known as "intermediate," or "hydraulic" limes. The white chalk as quarried contains 15 to 20 per cent. of water. The other raw material, limestone, occurs in large quantities in this country. Stones which may be excellent for building purposes are not necessarily suitable for lime ng. In the neighbourhood of Buxton a pure variety of limestone is worked, ; an excellent quality of "fat lime."

Limestone Deposits. Great masses of mountain limestone are widely distributed over the Derbyshire district, and disruptive agencies which have been at work in producing some of the peculiar characteristics of the country have also placed at our service various beds or layers of rock.

The layers of ancient deposits have been broken up and left near the surface, so that here and there beds of limestone of various ages are found, which have been thrown up from below. Thus, in the high Peak district of Derbyshire there is a great mass of limestone at Harper Hill, near Buxton, which is held to be formed of beds, termed "the lower beds," from strata hundreds of feet below the beds of limestone surrounding it.

Lime burning is an old industry in this neighbourhood, and the experience gained in burning the different types of limestone led to a classification and selection of the most suitable for the purposes required.

The purest limestones, such as those from Harper Hill Quarries, are well adapted for chemical work, such as the manufacture of caustic soda, bleaching powder, etc. They are also suitable for fine plaster work, and as a chemical manure for putting on the land.

Limestone Analysis. We give below some analyses of these limes, made during the past year (1905), from the limestones of the Harper Hill Quarries, Buxton.

In the first place we may compare the analysis of the limestone with that of the lime obtained from it.

LIMESTONE

Silica	0·20
Oxides of Iron and Alumina .	0·30
Carbonate of Lime	99·30
Magnesia	0·20
	100·00

LIME

Moisture and Organic Matter	1·10
Silica	·25
Oxides of Iron and Alumina..	·20
Lime (CaO)	98·20
Magnesia	·25
	100·00

It must not, however, be supposed that all limestones from this district contain the very high percentage of lime shown in these analyses.

To familiarise the reader with what he may expect to find in a good lime, we give two more analyses of samples prepared from Buxton limestones.

	"A"	"B"
Silica	2·14	7·00
Oxides of Iron and Alumina	0·54	3·60
Carbon Dioxide	0·35	0·13
Moisture and Organic Matter	0·75	2·27
Lime (CaO) Pure Lime	95·60	86·20
Magnesia	0·62	0·80
	100·00	100·00

It will be seen that all these samples are almost free from magnesia. This is a very important consideration when the lime is used for chemical purposes or for artificial manure.

Sample "A" contains 95·6 as against 98·2 per cent of caustic lime in the first analysis quoted, while sample "B" contains only 86·2 per cent.

This latter sample belongs to the class of "intermediate" limes. If we add together the amounts of silica and oxides of iron and alumina contained in it, we shall find that they amount to over 10 per cent. of the whole.

Later on we shall go into the question of slaking of lime, but we may mention here that it is a peculiar characteristic of the purest limes of the Buxton district that when slaked they fall to a fluffy, impalpable powder which readily passes through a fine sieve, leaving practically no residue, whereas it is said that equally pure limes from other districts, although they fall to powder, leave an appreciable residue on a similar sieve.

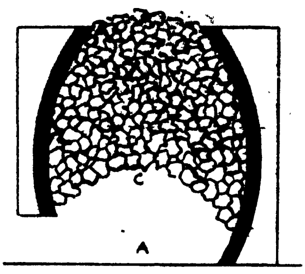
This latter class of material is more suitable for other purposes, such as the purifiers of gas works, where the gas has to pass between tiny particles of lime.

Effect of Silica on Lime. The differences in behaviour between these two classes of limes may perhaps be looked for in the manner in which the silica is contained or combined in the mass of carbonate of lime. In the Buxton lime it is probably in the form of very minute crystals diffused through, but not combined with, the lime. In other cases it is probable that a proportion of the silica is in combination as silicate. There is no doubt that the presence of any quantity of silicates, as in the form of clay, retards the slaking and renders it incomplete.

The limestones of the Lias formations [see GEOLOGY], such as are found in the Lyme Regis deposits, contain 10 to 30 per cent. of clay and a large proportion of iron. This has a curious effect upon the stone, which is blue inside and changes to a yellow-brown colour when exposed to the air. It yields a good "hydraulic" lime.

"Carboniferous" limestones are also worked, and sometimes yield a high grade of lime. Many limestones, often termed magnesian limestones, contain a varying proportion of carbonate of magnesia in conjunction with carbonate of lime. Such rocks are unsuitable for our purpose if the amount of magnesia exceeds 10 per cent. Generally, magnesian limestones yield "poor" limes.

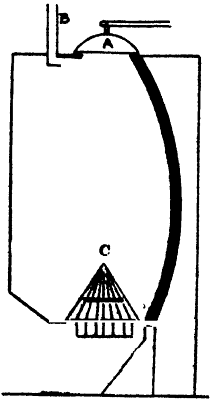
Lime Burning. The burning of chalk or limestone is carried on in kilns of simple construction. The kiln may be worked intermittently or continuously. In the first case, the kiln is cup-shaped, and is filled with blocks of chalk or limestone in such a manner that a space is left underneath for the fire [1]. For this purpose some large blocks are chosen and built into the form of an arch, which supports the rest of the stone above. In some cases such a kiln is very simply constructed from blocks of limestone, built in the form of a conical kiln open at the top, and coated inside and outside with clay. Where, however, a more permanent kiln is required a brick structure may be employed, the inner lining being composed of fire-bricks [1]. The ash of the burnt fuel in this type of kiln does not come in contact with the lime, which is, of course, an advantage. This form of kiln is known in this country as a "flare" kiln; the operation is carried on with a fire producing a long flame.



1. PRIMITIVE FLARE KILN

With more modern kilns built on these lines a properly constructed hearth, formed of arches of fire-brick, replaces the arch made from the limestone itself. Otherwise, the process is very similar.

The continuous method of burning is carried on in kilns, sometimes called "running" kilns. They are built higher than those already described, and the limestone and fuel are tipped into the kiln in alternate layers. As fast as the burning lime is removed from the bottom of the kiln, sufficient quantities of fresh limestone and fuel are fed into the top. These kilns, of course, have one drawback—the ashes of the fuel mix with the lime; but the process, being continuous, is more economical, and there is not the loss of heat unavoidably incurred when working flare kilns, where it is necessary to allow the kiln to cool down after each operation.

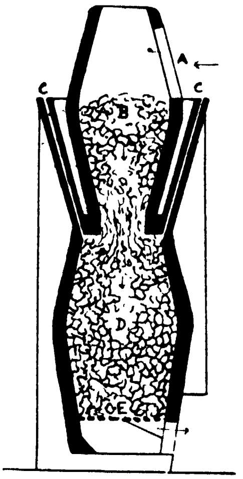


2. CONTINUOUS-BURNING KILN

Fuel for Lime Burning. Where wood is cheap, it forms a suitable fuel for some lime kilns, especially for the flare kilns. For the running kilns, coke is preferable to coal, as it usually gives a much purer and whiter lime. The quantity of fuel required varies very much with the efficiency of the kiln. A simple form of kiln will require one part of fuel to about every four parts of limestone.

With a more efficient type of kiln, the average quantity of coal burnt will vary from two to four parts for every 10 parts of burnt lime. Such a kiln may be built, say, 30 ft. high, in the form of a hollow spindle narrowing down at the top and bottom [2]. At the top there is a movable cover (A) for keeping off the draught during the burning, which can be opened for charging. The holes at the sides near the top draw off the fumes to a short chimney (B). Inside at the bottom is a conical shaped grate (C) of iron bars, the quicklime being drawn away from around this.

Modern Lime Kilns. A new and very efficient form of running kiln, constructed by Smidth, of Copenhagen, is shown in 3. It is devised with special attention to economy of fuel, and is best adapted to work a hard stone. The kiln is constructed in two halves, of which the upper (B) serves as a reservoir for limestone, which is introduced through an "eyehole" at A. Unlike the running kilns already described, only a small portion of the fuel is mixed with the limestone when put into the kiln, the greater part being introduced by the shafts (CC). The waste heat given off by the combustion going on in the lower chamber (D) is mostly retained by the limestone in B. At the bottom of the chamber (D), which is lined with fire-bricks, is a grate (E) with movable door, by means of which the burnt lime is withdrawn. The coal consumption of such a kiln should not exceed 20 per cent. of the burnt lime. We may mention that this is not the most suitable form of kiln for working a soft stone, as the movement of the stones down the kiln breaks and crushes them, and a considerable proportion of the output is reduced to a powder. Lime in good, large blocks finds a better market than broken stuff.



3. LATEST FORM OF CONTINUOUS LIME KILN

A very good form of kiln to use where lumps are required is the Hoffmann kiln. We have explained the construction and working of this kiln in the BRICKMAKING course, and have drawn attention to the very efficient manner in which the fuel is economised. We refer to it again in our consideration of cement, as it is used for burning cement as well as for bricks and lime.

At the Buxton Lime Works the chambers are filled with blocks of limestone, piled up in the same manner as if charged with green bricks, care being taken to leave the necessary channels for the air draft through the chambers, and for the fuel dropped in from the top. The lumps of stone are carefully chosen, and vary in size—they may be as small as a man's fist, or as large as his head. The drawback is the cost of labour, which must be considerable, as the chambers are "stacked" and "drawn" by hand. Still, there is a minimum of dust and small, broken pieces. Lime burnt in Hoffmann kilns, although effecting a considerable saving in fuel over the old flare kilns, has the disadvantage that the ash of the fuel mixes with the lime. The advantages and disadvantages of the three types of kiln may be summed up somewhat as follows.

Flare Kiln. Lime is in large lumps, free from ash, but the process wastes fuel.

Running Kiln. Lime is much broken into small pieces, and mixed with ash, but the process economises fuel.

Hoffmann Kiln. Lime is in large lumps, and mixed with ash. The process economises fuel, but the cost of labour is heavy.

There are also continuous kilns, in which the fuel does not come into contact with the lime.

Some of the more modern kilns have been devised to burn the lime by means of producer gas.

Quicklime and Slaked Lime. As we have already explained, the lime varies in quality according to the chalk or limestone from which it was derived. The fat limes obtained from pure materials are remarkable on account of the vigorous manner in which they combine with water. To this process the term "slaking" is given. It consists, chemically speaking, in conversion of the quicklime (oxide of calcium) into hydroxide (also known as hydrate) by combination with water:

$$\frac{\mathrm{CaO}}{\text{Quicklime}} + \frac{\mathrm{H_2O}}{\text{Water}} = \frac{\mathrm{Ca(OH)_2}}{\text{Slaked lime}}$$

There is one point we should notice which is not always sufficiently appreciated—namely, that in slaked lime the water is in chemical combination with the lime. If we slake quicklime with exactly the right amount of water, the resulting slaked lime is a *dry* powder.

As will be seen, 100 parts of lime will require 32 parts of water, which is, roughly, a third by weight. When such water is added to a pure or fat lime, the lime begins to swell and get hot, giving off steam; the lumps crack, and, eventually, the hard block falls to a fine powder.

This slaking of lime is accompanied by an increase in volume. Thus, 100 parts of fat lime will give 250 to 300 parts of slaked lime. Poor limes and hydraulic limes do not slake readily, and a process which occupies a few hours with fat lime may take days in the case of hydraulic limes. The larger the proportion of clay and silicious matter contained in the chalk or limestone, the more hydraulic the lime, and the less it resembles fat lime.

Magnesium limestones give poor limes. If the percentage of magnesium exceed 10, the lime slakes slowly, and anything like 20 to 30 per cent. of magnesia makes the lime practically useless.

On the other hand, it is stated that some good hydraulic lime has been prepared from magnesia limestones. The lime, however, requires to be rather more strongly burnt.

A fat lime is easier to produce than a hydraulic lime. The larger the percentage of clay and silicious material, the lower the melting point. Hence, in burning hydraulic limes, if the temperature be not carefully regulated, it may rise sufficiently to fuse partially or to over-burn the lime; or, in other words, "clinker it." The hydraulic limes do not swell to the extent that the fat limes do when slaked. A hundred parts of hydraulic lime will yield somewhere about 150 parts of slaked lime.

The terms "hydraulic" lime and "intermediate" lime appear to cover much the same ground. By hydraulic lime, we understand a lime which is capable of setting under water. An intermediate lime is one made by burning a limestone or chalk containing some clayey matter, owing to which the resultant lime holds a position somewhere between a fat lime and a true cement. [See CEMENT.]

Hydraulic Limes. As we have already explained, limes obtained from chalk or limestone, with a suitable percentage of clay naturally bound up in them, yield a lime which does not slake very readily. Where limestone contains 8 to 12 per cent. of clayey matter, the lime produced is termed "moderately hydraulic," and instead of falling quickly into powder and crumbling under the action of water, it gives out little heat, and appears hardly to be affected. As a matter of fact, absorption of water does take place, and a substance is produced which gradually sets hard in the course of 5 to 20 days. If placed under water, it remains pasty.

Limes prepared from limestone containing 15 to 18 per cent. of clay may be termed hydraulic, as in the course of a few days they set to a hard mass, even under water. The mass is not so hard as that produced by Portland cement, which we shall discuss later, but has about the consistency of a soft stone. If the limestone contain as much as 20 or 30 per cent. of clay, the resulting lime is very hydraulic. It does not appear to slake at all when moistened, and the lumps do not swell. A paste gradually hardens under water in 2 or 3 days, and on further standing it gets much harder still, yielding a stone-like mass, which will stand the action of running water. These hydraulic limes approach cement in quality and behaviour, as the proportion of clay in the original limestone is increased.

Need for Care in Burning. Speaking generally, the clayey matter in the burnt lime is not in that intimate state of combination with the lime (calcium oxide), which we find in Portland cement. Nor should the temperature of the kiln be such as to fuse (or clinker) the mass. If this should take place, calcium oxide no longer combines readily with water, and the mass refuses to slake as a lime should. This is why the burning of hydraulic limes requires so much more care than the burning of fat limes. The danger of clinkering will also be increased if the lime contain much iron salts, or alkalies, owing to the formation of easily fusible silicates. As a rule, clinkered lime is fused only on the outside, and contains a core of quicklime. Even when every care is taken in slaking the lime, such particles of quicklime will remain, and, protected by an outer layer of silicate, will not slake with water, or else slake very gradually, perhaps after the lime has been converted into mortar. When this takes place, the lime swells and, expanding, cracks, bringing about the destruction of the mass.

When a mortar made from a fat lime has set, the subsequent process of hardening, or "induration," appears to be merely due to the combination of the lime with the carbonic acid of the air, with the formation of calcium carbonate.

With hydraulic limes, the induration is caused by a combination of the silica and alumina of the clayey matters in the presence of water with the lime (calcium hydroxide). These hydrated silicates and aluminates of calcium are formed subsequent to the setting of the mortar.

The peculiar effect produced by the presence of clay in the limestone are gone into more fully under the heading of CEMENT.

Slaking Lime. Mortars, for the purpose of building construction, consist of a paste of lime, mixed with sand. The first stage in the preparation of mortar is the slaking of the lime. This is conveniently effected by placing the lumps of lime in an iron basket, and immersing for a short time in water. The lime is removed before it has swollen much, and put on one side, when the slaking will complete itself, and the whole will fall to powder. Instead of doing this, the lime may be sprinkled with water, or else exposed to a moist atmosphere. Care has to be taken to use the right sort of water for slaking; such water should be free from saline matter, especially sulphate of calcium. River-water is, in most cases, suitable, but sea-water is said to retard the rate of setting. On the other hand, Smeaton used sea-water in slaking the lime used for the old Eddystone Lighthouse, with excellent results. However, on dry land, any quantity of salt in the water would probably cause "efflorescence" in the mortar if used above ground—that is to say, the saline matter would gradually crystallise out on the surface.

Mortar. Mortars were prepared by the ancients, and many of the analyses made show that such mortars did not differ essentially from those we make nowadays. The Pyramid of Cheops, in Egypt, is built of stone cemented with a sort of mortar, probably composed to a large extent of plaster of Paris. This pyramid was built somewhere about six thousand years ago. There are plenty of examples of the ancient use of mortar, as in the buildings erected by the ancient Phœnicians, Greeks, and Romans.

When making mortar care must be taken to see that the lime is thoroughly well slaked. This presents no difficulties in the case of fat limes; but hydraulic limes take several days to slake, and to promote the action, the lime after moistening should be covered over with sand to keep the heat in, and the slaked lime should be put through a sieve to remove any unslaked lumps. Many hydraulic limes should be finely powdered before any attempt is made to slake them. If any unslaked portion should remain in the mortar after it is used, gradual slaking takes place with swelling of the lime and disruption of the mortar.

Mortar Sand. The sand used should be what is known as *sharp* sand, the particles of which are angular and not rounded or waterworn. Ground brick, or other similar material, can be used. The best proportion of sand to use depends upon the type of lime. Hydraulic limes usually require less than fat limes.

Sand is used for various reasons. Firstly, it cheapens the mortar, and secondly, it separates the particles of lime so that the carbon dioxide gas of the atmosphere can get at them. We must carefully distinguish between the *setting* and *hardening*, or *induration*. The setting is due to the absorption of the excess of water; the hardening of mortar depends upon the conversion of the lime into carbonate of calcium:

$$\frac{\text{CaO}}{\text{Lime}} + \frac{\text{CO}_2}{\text{Carbon dioxide}} = \frac{\text{CaCO}_3}{\text{Calcium carbonate}}$$

This latter forms a hard crystalline rock adhering to the particles of sand or any other rough surface. The crystals which go to form the mass may possibly adhere more strongly to the particles of sand than they do to each other, and hence mortar containing sand has a greater resistance to crushing than mortar prepared from lime alone.

Carbonic acid penetrates very slowly into a mass of mortar, and after twelve months only the outer one-eighth or quarter inch has been carbonated.

On the other hand, it has been found by analysis of very ancient mortars that there is sufficient carbonic acid in them to combine with the whole of the lime, so that presumably, given sufficient time, carbonic acid will penetrate right through a mass of mortar, converting the whole of the lime into carbonate.

Sand is also of use in that it prevents excessive shrinking of the mortar in drying.

Where hydraulic or intermediate limes are used the hardening of the mortar is due very largely to the formation of hydrated silicates already spoken of. In this form the silica is very slightly soluble, and the mortar prepared from such limes is exceedingly durable.

Use of Chemical Analysis. The chemical analysis of limes and limestones often results in yielding valuable information as to their suitability for the purpose for which they are required. We may, for instance, wish to know whether certain limestone is suitable for lime burning, and what sort of lime it will yield. These queries can, to a large extent, be answered if we first determine the proportion of lime (calcium oxide), magnesia, and silica contained in it. If the magnesia be high, the lime will be useless for most purposes; if there be very little silica, we may expect to produce a fat lime, and so on. Then again, a sample of quicklime should be tested for the proportion of free oxide of calcium and carbon dioxide. Too large a proportion of carbon dioxide will mean that the limestone has not been properly burnt, or that the quicklime has been kept too long and has consequently deteriorated owing to the absorption of carbon dioxide from the atmosphere. Slaked lime sometimes requires to be tested in a similar manner. It is also important to determine the proportion of water it contains, over and above that combined as calcium hydroxide, as, of course, we do not wish to pay for water when we are buying lime. The same methods of analysis are mostly applicable both to limestone and lime.

In the Laboratory. In the first place we can make a chemical analysis, and we shall give a brief outline of the method on the ordinary lines. The substance under examination should be dissolved in hydrochloric acid and the solution concentrated to dryness, to render the silica insoluble. On taking up with water and filtering, a residue will be left on the filter paper consisting of silica and traces of undecomposed silicates. For most purposes a further separation of this residue is unnecessary, and we may reckon the whole as silicious matter. The filtered solution is precipitated with ammonium chloride and ammonia solution. The iron and alumina are thrown down together and may be filtered off, ignited, and weighed if necessary. To the solution containing the lime and magnesia an excess of ammonia is added when ammonium oxalate precipitates the lime as calcium oxalate.

Filtered off and strongly ignited, it is converted into calcium oxide and may be weighed as such. In the filtrate from the calcium oxalate precipitate, the magnesia is precipitated as phosphate by means of sodium phosphate in a solution strongly alkaline with ammonia.

Lime in Quicklime. As we have said, quicklime is not necessarily pure oxide of calcium, and if we want to know how much of this latter is contained in a sample, we take 100 grammes and slake it completely, make up the milk of lime to half a litre, and after thoroughly agitating it, take an aliquot portion, say, 25 cubic centimétres, which will represent 1 gramme of quicklime. We then titrate this with a normal solution of oxalic acid with phenol phthalein as an indicator, shaking well after each addition of acid. [See ANALYTICAL CHEMISTRY.] The colour is discharged as soon as all the free lime has been saturated, but before any carbonate of calcium which may happen to be present is attacked. Each cubic centimétre of normal oxalic acid solution is equivalent to ·028 grammes of lime.

Lime concluded

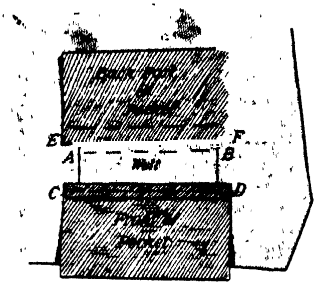
continued from page 1293

SUITS FOR LITTLE BOYS

Sleeves and their Linings. Sewing on Buttons. Making the Vest. Making and Putting in Pockets. Making up Knickers

By Mrs. W. H. SMITH and AZÉLINE LEWIS

BASTE the forearms of the sleeves together and stitch ; take out the bastings, open and press the seams on the narrow side of sleeve-board ; mark up from the thread marks on wrong side the depth required for the stitching—in this case 3 in.—draw a line with chalk, and tack through with white cotton.



33. POCKET READY FOR STITCHING

Take a strip of cloth, 2 in. wide and 12 in. in length, crease through the centre [**32**, p. 1293], place this on the tacking line and baste round to hold in position ; turn over and machine ¼ in. on either side of the tacking line. Tack the back seam, keeping the thread marks at wrist and machine-stitching of cuff part evenly together ; stitch, take out the tackings, open and press, as described for the fore seam ; remove the basting from the cuffs, turn up the bottoms to the thread marks, baste smoothly round the hand and serge the two raw edges together. Place the narrow end of sleeve-board inside the sleeve, and press both sides of the cuff over a damp cloth ; remove the cloth and re-press.

Linings for Sleeves. Tack and stitch the linings together, place the lining under part to under part of sleeve, keeping the top ½ in. above the top of sleeve, and the seams together evenly ; 3 in. down from the top tack the lining to the turning of cloth, back and front. Put the hand through the lining, take hold of the bottom of sleeve, turn the lining over, and draw the sleeve through. Turn the lining up ¼ in., keep the seams together and fell neatly over the hand ¼ in. from the raw edge. Turn the lining back from the top, to leave room to insert the sleeve, but before doing this pare all canvas and lining from the armhole.

Place the front seam of the left sleeve to the inset mark, and the back seam to back inset, as at J^{a} [**15**, p. 1112] ; baste in the sleeve from the inside, keeping it rather tight at the back and easy under the arm ; continue round the sleeve-head, and either stitch or sew in with strong thread. Press open on the sleeve-board, just damping seam before doing so. Do not stretch the back of armhole, but slightly stretch the front near the shoulder. Serge the lining of coat to armholes and fell the sleeve lining over. Now fell the neck, shoulders, seams, bottom, and facing to the corresponding portions.

Before putting on the buttons, should there be any shine caused by the pressing, take a clean cloth, wrung as dry as possible, and a warm iron, and go carefully over the right side of coat.

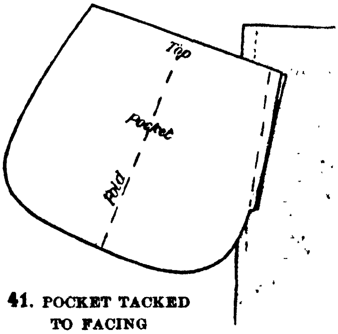
The Buttons. Have a No. 4 needle and double thread, twisted and waxed, place the needle through the cloth and canvas, on the right side. Take the button, pass the needle up through one hole, and down through the opposite one, then through the cloth and canvas, but before pulling the thread tight, place a bodkin through the loop—this is to raise the button for the stem, or stand—pass the needle and thread through the holes three or four times ; remove the bodkin, pull the button up sharply, twist the thread round the stem tightly three or four times, and finish with two or three backward and forward stitches through cloth and canvas.

Making the Vest. After the vest is cut out and thread-marked, as already described in the making of the coat, the pockets are the first thing to be taken in hand. The welt must be cut a seam wider than the opening on each side, and twice the depth it is required to be, in this case 1½ in. wide and 3½ in. long.

The pocket must be cut 1 in. wider than the opening, to allow ½ in. on either side, and just long enough to escape the bottom of vest by ½ in.

Place the welt on the right side of vest, with one edge quite close to the thread marks of pocket-opening, and baste to this, as from A to B in diagram **33**. Take front part of pocket, place to the lower edge of pocket (leaving ½ in. on each side), and on this place a linen stay ¼ in. wide, and tack together, with the front part of pocket to the lower edge of welt, as from C to D.

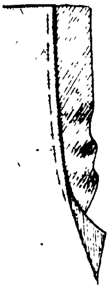
Now take back part of pocket, place one edge directly above the thread mark of opening, and the other edge towards the neck of the vest, as from E to F. Machine-stitch ¼ in. above and below pocket-opening (not the ends); then machine front portion of pocket to lower edge of welt, as from C to D [**33**].

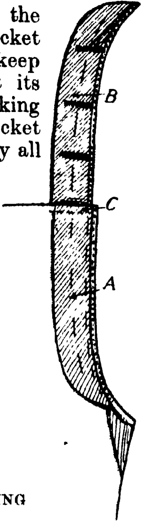


41. POCKET TACKED TO FACING

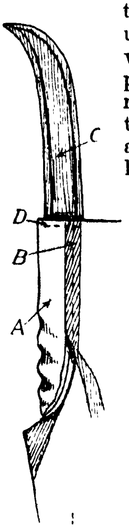
Cut the opening to within ¼ in. of the end, nick the corners as in flap-pockets, remove the tackings, open the bottom seam—*i.e.*, where the welt has been stitched on—and press. Chalk-mark the welt the depth it is required, tack a linen stay on wrong side, ½ in. from seam, fold over to chalk mark—with the stay inside—baste, and stitch the folded-over edge.

Turn the pocket through the opening, nicking the corners to make it lie flat; turn the bottom of vest back over the pocket-mouth, and stitch the pocket to the lower edge of inturn, to keep it in position and to prevent its being pulled inside out when taking anything from it. Tack the pocket and stitch round, and pare away all superfluous cloth and lining from the under part of welt, to make the corners as thin as possible. Turn in the corners and serge them to keep them in position; stitch the ends down neatly, by hand, by means of prick-stitch, and press well on the wrong side over a damp cloth.

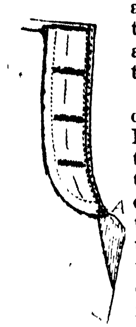

34. FLY FACING



35. LEFT FORE PART OF FLY

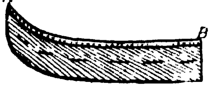


38. BUTTON CATCH

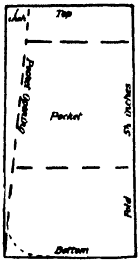


37. BUTTONHOLE PORTION

Fronts of the Vest. We are now ready for the canvas (½ yd. of black vest canvas will be required). Cut the canvas to the shape of fore part, baste on loosely all round, and pare away the width of a seam from the edges and ⅜ in. from side of seam. Take a linen stay ½ in. wide, baste it on either side to canvas and cloth, beginning at the bottom right-hand corner, holding it tight at the corners and from waist to bust; continue the stay round the neck, turn the front over, place the facing on (cut as in **19**, p. 1291) right side underneath, and projecting ⅛ in. over the edges. Baste and stitch ⅛ in. from stay tape, remove the basting, turn the facing right side over the canvas, work the corners out nicely and sharply; baste round from the wrong side, keeping the seam ⅛ in. in from the edge, as for coat-facing. Serge the inner edge to canvas only, turn in the cloth edges round the armhole, and serge to canvas.



36. BUTTONHOLE PART OF FLY



40. CUTTING OUT POCKET

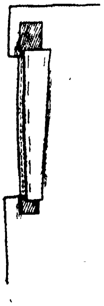
Slit the canvas on the shoulder 3 in. down [**29**, p. 1293], remove the bastings and press with a damp cloth all over; tack the top of facing to the side seam. Now baste in the lining (it must overlap the facing ¼ in.), fell to the armhole, and from bottom to top. Stitch the edges of both fronts to match the coat, and space the buttonholes 3 in. apart, the first one being ½ in. from the top and ¼ in. larger than diameter of button.

Stitch up the backs, both the light (for lining) and the black (for the outside). Place the black lining on the table, seam underneath, put the side seam of vest right side to the lining, then place the light lining, right side underneath, on to wrong side of vest; baste the shoulder and both linings together, also tack the side seam. Baste the linings together round the armhole and at the bottom to the seams; machine, and remove the tackings.

Treat the other side exactly the same. Now put the hand through the neck, take hold of the top of vest, and draw through a little at a time very carefully; turn in the neck, machine, and press all round back and front.

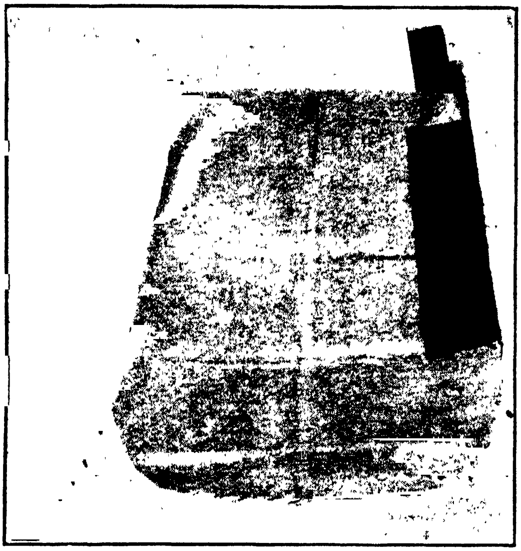
Making the Knickers. Face the forks of fore parts with linen. For this take a piece 3 in. square, fold corner-wise, and cut through; turn in the longest edge and stitch; place on the inside of forks and stitch close to the edge; then cut the linen away level with the cloth.

The flies must now be cut 1½ in. wide, and curved round at the bottom to within 1½ in. of fork [**19**, p. 1291]. Two pieces of cloth and two of linen will be required for these, and an extra strip of linen for button stay ¾ in. wide. Baste one piece of linen to the right side of left fore part [**34**]; stitch the edge, remove the basting; turn the linen over and baste again, working the edges over well, so that the cloth is ¼ in. under (the linen must on no account show on the right side), and baste through the centre to keep in position [A, **35**]. Now prepare the under part for buttonholes in the following manner.


39. POCKET OPENING WITH FACING

Place one piece of linen on the table, the fork away from the worker; lay the cloth on, wrong side uppermost, and stitch from the fork to the top, as from A to B. Turn the cloth over and baste the edge, working the cloth under ⅛ in.; baste all round and stitch ½ in. from the edge; remove basting from edge, and press [**36**].

Now work the buttonholes 2 in. apart, the first one being 2 in. from the top, and just large enough for the buttons to go through comfortably [B, 35]. When these are made, lay the fore part on the table, right side uppermost, place the fly on, and stitch along the top ⅛ in. in from edge [C, 35]. Turn fly over to wrong side, baste in position; turn the fore part over, and stitch from top to bottom, keeping just beyond the bar ends of buttonholes [37]. Remove the basting and press on the wrong side over a damp cloth, then catch the fly to the fore part with three or four slanting stitches between the buttonholes, to keep the fly in place, and well secure the end of it to the stay, as at A, 37.



42. INSIDE OF POCKET WITH FACING

Place the right fore part on the table, right side uppermost, baste on the button and catch, keeping the top level with the top of knickers; machine from the top to the fork, ¼ in. from edge; open and press the seam, and baste the linen stay ¼ in. over this [A and B, 38]. Turn in the edges of linen facing ¼ in. on each side; and place on the top of button catch, on the right side; stitch across the top, turn over [C and D, 38], baste in position with the straight edge ¼ in. over the seam to hide this. Baste the curved side, turn over on the right side, and stitch ⅛ in. to the left of seam. Turn over again, and stitch the curved part; remove the bastings, and press.

Putting in the Pockets. Nick the opening on the fore parts at the seam A at waist, and also 5½ in. below this. Take a linen stay, 1¼ in. wide and 1½ in. longer than the opening, and tack to this from 1 in. above the nick on wrong side.

Now cut the facings. These should be of cloth 1 in. longer than the opening, 2 in. wide at top, and 1 in. at bottom. Place one piece on the right side of left fore part, with the widest part to the top, ½ in. above and below the opening; baste and stitch [39].

Remove the basting, open and press on sleeveboard; turn the facing back, baste again, keeping the edges even, and the seam out at top and bottom—*i.e.*, where the nicks come [39]; press over a damp cloth to make the seam as thin as possible; stitch and remove basting.

In good tailoring, "strong and thin" should be the motto; the first to apply to the making and finishing, the second to seams and edges.

Now cut the pockets, which must be of "pocketing," and 11 in. square. Fold through the centre, and shape in this manner. Draw a chalk line across, 4 in. up from the bottom, and 5½ in. from this draw another for pocket-opening. At the top, one side must be sloped away 1 in. to make it narrower than at the bottom [40].

Cut the cloth facings for back of pocket 2 in. wide and 6½ in. long; open a pocket, place one edge on the front facing, as near the edge at the bottom as possible, and 1 in. from edge at the top, with the nick of pocket on the end of facing [41]. Stitch and turn the former back, creasing it down with the thumb.

Take the back facing, place on the pocket mouth, ½ in. above and below the opening, turn the back of pocket over to the facing, place the nick to the bottom of this. Turn facing and pocket back together and baste, then stitch the inner edge of facing to the pocket. The inner edge must be turned in if the material be thin or likely to ravel [42].

Fold the pocket over again, with the facing turned back. Take a piece of linen 1½ in. wide, folded in half; turn up edges ½ in. at the bottom, and stitch the raw-edged side to the edge of pocket. Crease the seam back, turn the pocket over, placing the nicks together, and stitch the bottom of pocket from the fold to nicks. Trim the pocket round, turn inside out and stitch again from the nicks to the fold. Now place the back facing on the pocket mouth, with the pocket turned back; secure well to the nicks at both ends of pocket.

Continued

Continued from page 1258

SHORTHAND

Tenth Instalment of the Special Course of Shorthand Taught by Sir Isaac Pitman & Sons on their Twentieth Century Plan

By Sir ISAAC PITMAN AND SONS

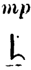
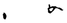
TWO abbreviating devices, which are employed with much success in Pitman's Shorthand, are described in this lesson. The first is the systematic omission of medial consonants and the contraction of the outlines for certain long words of frequent occurrence; and the second, which is known as phraseography, consists of the joining of two, three, or more words without lifting the pen.

Contractions. The consonant *p* is omitted between *m* and *t*; thus

pumped,

plumped,

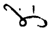
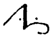
bumped,

tramped,

damped,

stamped,

thumped,

camped.

P between *m* and *sh*; thus


presumption,

redemption,

assumption.

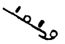
T between *s* and another consonant; thus

post,

postage,

postage stamps,

post office,

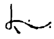
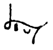
postpone,

postponements,

most,

mostly,

honest,

honestly,

test,

testimony,

testimonial,

testament.

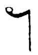
K or *G* between *ng* and *t* or *sh*; thus

distinct,

distinction,

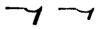
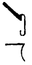
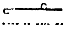
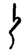
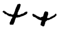
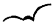
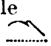
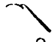
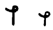
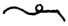
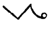
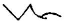
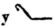
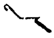
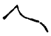
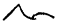
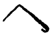
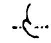
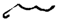
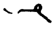
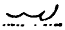
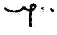
distinguish,

anxious,

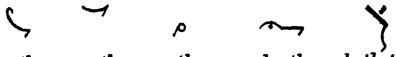
sanction,

sanctity.

The following special contractions should be committed to memory.

List of Contractions.

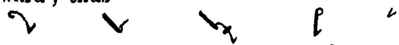
Acknowledge-d	
altogether	
anything	
architect-ure-al	
Better than	
Catholic	
character	
characteristic	
Danger	
dangerous	
destruction	
difficulty	
disinterested-ness	
doctrine	
domestic	
Enlarge-d	
especial-ly	
essential-ly	
establish-ed-ment	
everything	
expect-ed	
Govern-ed-ment	
Immediate	
immediately	
impossible	
impracticable	
improbable-bly-ility	
inconsistent	
inconsistency	
influence	
influenced	
influential	
information	
instruction	
interest-ed	
irregular	
Kingdom	
knowledge	
Magazine	
manuscript	
messenger	
mistake-n	
more than	
Natural-ly	
neglect-ed	
never	
nevertheless	
next	
nothing	
notwithstanding	
Object	
objection	
Parliament-ary	
peculiar-ity	
perform-ed	
performance	
performer	
phonographer	
phonographic	
practice-d-cal-ly	
practicable	
probable-bly *or* probability	
prospect	
public-sh-ed	
publication	
Rather *or* writer	
rather than	
reform-ed	
reformation	
reformer	
regular	
remarkable-ly	
represent-ed	
representation	
representative	
republic	
republican	
respect-ed	
Reverend	
Satisfaction	
satisfactory	
something	
stranger	
subject	
subscribe-d	
subscription	
surprise	
Temperance	
thankful	
together	
transcript	
transfer	
transgress	
transgression	
Unanimity *or* unanimous	
understand	
understood	
unexpected-ly	
uniform-ity	
uninfluential	
uninteresting	
unsatisfactory	
Whatever	
whenever	
Yesterday	

Tick *The*. A slanting tick, joined to the preceding character, and usually written downward, is employed to represent *the;* thus



for the, *in the*, *is the*, *make the*, *both the*.

When it is more convenient, the tick is written upward, thus



from the, *above the*, *before the*, *said the*, *on the*

In order to keep *on the* distinct from ᵛ *I*, the first stroke must be written sloping The tick *the* must never be used initially

Phrase *Of the*. The phrase *of the* may be expressed by writing the two words which it connects CLOSE TO EACH OTHER, and in this way indicating that one is "of the other, thus *plan of the work*, *some of the inductions*, *result of the measure*, *a statement of the actual condition of the country* The method of imitating *of the* cannot be mistaken, in practice, for this mode of expressing *con* or *com* When *of the* is followed by *con* write the dot for *con*, thus *close of the contest* These methods must not be employed after a dot or dash vowel sign, as *a condensed account*, *two of the principal men*, would not be distinct

Phraseography. The phonographic characters for a common phrase, consisting of several words naturally related to each other, are joined together and written without lifting the pen, for example *may be* is written thus ╲ and ᵛ *I have been*, thus These groups of joined characters are known as phraseograms, and the employment of this method of writing is styled phraseography Phraseograms should not be made of words that can only be joined with difficulty, nor should they be too long, or carry the pen too far from the line The phraseograms in the following table should be copied several times till they can be readily used

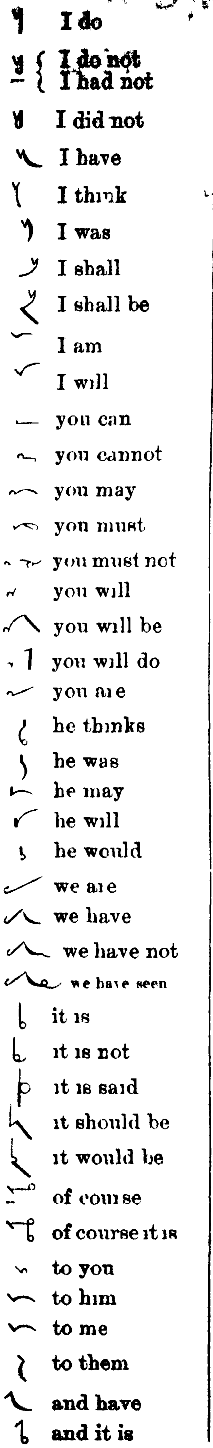
In phraseography *I* is frequently abbreviated by writing the first stroke only, for example represents *I am*, and *I can*

Generally, the first logogram in a phrase must occupy its proper position, thus *can be*, — *you can*, but a logogram written in the first position may be raised or lowered to accommodate it to the following character, thus *I had*, *I see*

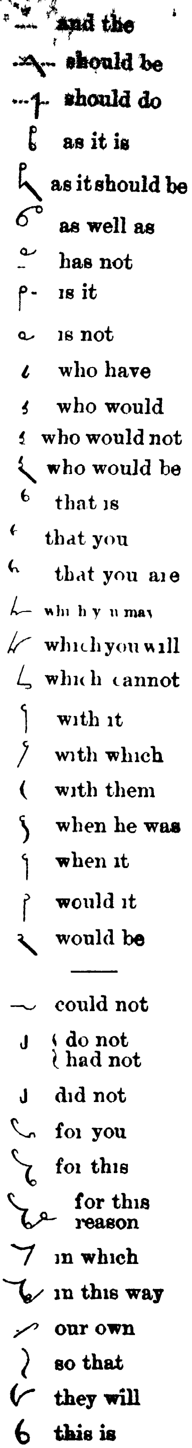
A logogram or phraseogram may be written over or close to a word to express *con* or *com*; thus *you will comply*, *I am content.*

There or *their* may be added to a curved full-length logogram by doubling it, thus *for there*, *from their*, *in their*, *if there.*

Phraseograms



I do
I do not
I had not
I did not
I have
I think
I was
I shall
I shall be
I am
I will
you can
you cannot
you may
you must
you must not
you will
you will be
you will do
you are
he thinks
he was
he may
he will
he would
we are
we have
we have not
we have seen
it is
it is not
it is said
it should be
it would be
of course
of course it is
to you
to him
to me
to them
and have
and it is



and the
should be
should do
as it is
as it should be
as well as
has not
is it
is not
who have
who would
who would not
who would be
that is
that you
that you are
which you may
which you will
which cannot
with it
with which
with them
when he was
when it
would it
would be

could not
do not
had not
did not
for you
for this
for this reason
in which
in this way
our own
so that
they will
this is

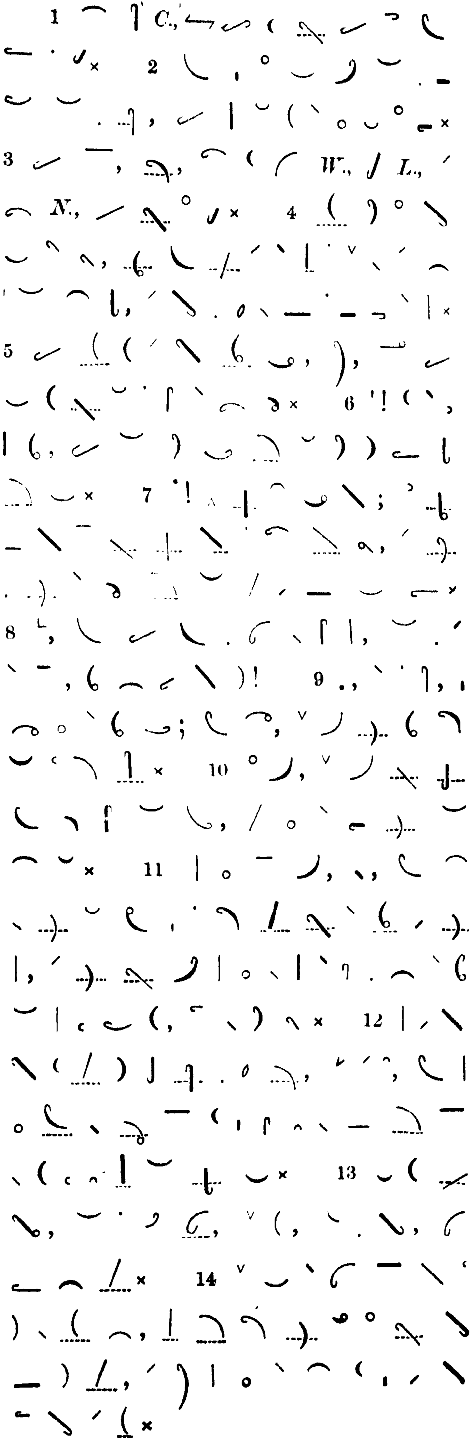
Conclusion. In the preceding lessons the student has had placed before him all the essential features of Sir Isaac Pitman's system of shorthand. He should make himself thoroughly familiar, not only with the phonographic characters, but with the principles which govern their employment, so that he may correctly use the signs for the representation of any words in the language. He is cautioned against introducing any abbreviations not sanctioned by the rules, because these have been framed as the result of over sixty years' employment of the art in all descriptions of note-taking, and the chief object aimed at has been the avoidance of forms which would tend to illegibility, ambiguity, or error.

The student has now to attain speed in the writing of shorthand, so that he may employ the art in taking notes from dictation in the office, or in recording speeches and addresses for newspaper purposes or otherwise. In the acquirement of shorthand speed, the most important factor is PRACTICE. This should at the outset take the form of note-taking from the reading of another person at a rate which will enable the writer to record every word that is uttered. As the note-taker becomes more dexterous, or, in other words, increases his speed, the reader can quicken his rate of utterance, and the note-taker will thus gradually attain to a higher speed of writing.

In choosing matter for dictation practice, regard should be paid to the particular purpose for which the art is being acquired. A book of commercial letters and business forms will provide the most advantageous practice for the young shorthand correspondent; the private secretary should select such works as are likely to prove useful in his daily work; and the embryo reporter should follow the dictation of speeches, lectures, and parliamentary debates. A number of useful works for this purpose are included in the catalogue of shorthand works published by Sir Isaac Pitman & Sons, Ltd., 1 Amen Corner, London, E.C.

From the beginning of his speed practice, the student should strictly avoid a careless and inaccurate style of writing; slovenliness in note-taking will result in either illegibility or inaccuracy, which cannot but prove a serious drawback to the successful use of shorthand. The student should cultivate the ability to read his notes with readiness and accuracy. It is a good practice to read over systematically to the dictator a considerable portion of the notes which have been written a day or two before, taking careful note of any divergencies from the dictated text, and their cause. Occasionally, portions of the notes should be written out in longhand, or typewritten, in order to test the student's ability in accuracy and facility in transcription. The reading of shorthand printed in the Reporting Style is most essential, in order that the student may gain a wide familiarity with outlines.

KEY TO EXERCISE IN LAST LESSON.



Shorthand Concluded

Group 7

CLERKSHIP

10

Continued from page 1320

KEEPING THE JOURNAL

Procedure in Scottish Banks. Acceptances. Origin of the Journal. Double Entry. Record of Bill Transactions

By A. J. WINDUS

On examining the pass book, it is found that the discount debit is entered under date of September 26th among the cheques drawn by Bevan & Kirk, and honoured by the bank. As a matter of convenience, therefore, Bevan & Kirk treat the debit slip as if it were a cheque which they themselves had drawn in favour of their bankers, and enter the amount of it on the payment side of the cash book under the date when it was received.

It would be logically correct not to do this, but to make the entry on the opposite side of the cash book, putting the amount in the column specially provided for discounts allowed ; but then it would not be so easy to make the pass book agree with the cash book as under the plan adopted.

Procedure in Scottish Banks. In Scottish banks, the procedure is slightly different. Here, the net amounts only of discounted bills are credited to customers' accounts. It is usual, however, for customers to present their pass books when paying in money and cheques, etc., which is not the case in England. Suppose, therefore, the bill for £20 10s. 6d. had been sold to a bank in Glasgow ; directly it had been discounted, the net amount would have been written in the pass book. The discount charge of 3s., being already involved in the net figure of £20 7s. 6d., would not, of course, appear as a separate item on the opposite side of the pass book. In the event of the pass book not being produced at the time the bill was discounted, a duplicate credit slip showing the net proceeds of the bill would be issued to the customer, the bank retaining the original.

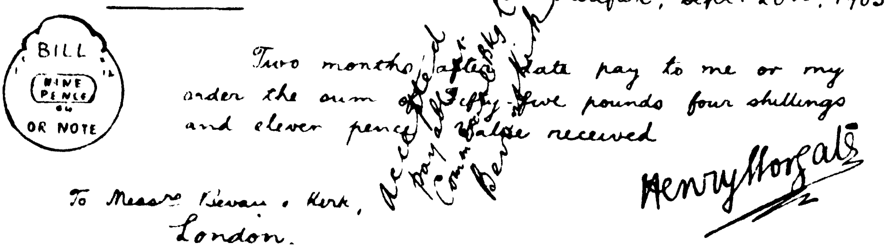
English and Scottish Pass Books. Probably, the most convenient way of recording in the trader's books of account the transaction as here outlined would be to make the entry on the debit side of the cash book as explained, but in skeleton form—that is, with the amount left blank to be filled in immediately the correct figure was obtained from the bank. There is a margin of 3s. between the total of £20 10s. 6d., for which the acceptor, J. Wake, should receive credit, and the lesser sum of £20 7s. 6d., with which he would have been credited through the cash book had the acceptance been discounted in Glasgow. Such margin or difference may either be treated as cash discount, and entered in the discount column of the cash book alongside the principal amount, or, preferably, may be dealt with through the journal—a book that will come under our notice in relation to the next transaction taken. Further remarks on points of difference between English and Scottish pass books, and pass book entries, may be postponed until the method of reconciling the pass book and the cash book claims our attention.

Acceptances. There still remain some features of transaction (*n*) which would repay our scrutiny, but since more than one of them will be reproduced in (*m*), let us now make that the subject of inquiry.

> Transaction (*m*), Sept. 25th. Accepted Henry Norgate's draft at 2 months for £55 4s. 11d., payable at the Commercial Banking Company, in settlement of account to the 19th.

It is not improbable that this draft was accepted by virtue of a standing arrangement between Bevan & Kirk and Norgate, under which the latter regularly sends drafts for acceptance along with the monthly statements of account. By accepting Norgate's drafts, Bevan & Kirk lose the cash discounts, but obtain an extension of credit, which is worth something to them, no doubt.

The draft will read somewhat as follows :



£55 . 4 . 11

BILL
NINE PENCE
OR NOTE

Halifax, Sept. 20th. 1905

Two months after date pay to me or my order the sum of Fifty-five pounds four shillings and eleven pence Value received

Henry Norgate

To Messrs. Bevan & Kirk,
London.

Accepted
payable at
Comm Bkg Co Ld
Bevan & Kirk

It may be that when Norgate receives the acceptance he will discount it as Bevan & Kirk discounted the one received from Wake. But the question is: How is the transaction to be dealt with in Bevan & Kirk's books? Acceptance of a bill of exchange is not payment, but merely a promise to pay at a future date. Therefore, the transaction should not appear in the cash book, which is a register of receipts and payments. Certainly the bill book is affected, because the rule is that all bills must be entered therein; but the bill book in the system we are describing is not so much a book of original as a book of additional entry, and the transaction must accordingly be enrolled, not only in the bill book, but also in a journal.

Remembering that the bill book is divided into two parts, one part being reserved for bills receivable, and the other for bills payable, we first decide that from Bevan & Kirk's point of view the acceptance is a bill payable, because it represents an amount payable by the firm, and then we enter it in the form here given, in the section of the bill book devoted to bills payable.

Origin of the Journal. It has been stated that "journal" and "book of original entry" are synonymous terms. There are several journals mentioned in our list, as day book, invoice book, outwards returns book, etc. There is also one book bearing the title of Journal with a capital J. Other books of original entry are journals, but this book is *the* Journal, being a survival of the celebrated system of bookkeeping indifferently known as the Italian or Venetian method. To the Genoese and Venetian bookkeepers of the Middle Ages belongs the credit of having invented or rediscovered the art of double entry. Three books formed a complete set—the Memorial, the Journal, and the Quaderno, or Ledger. The first-named is sometimes met with even yet under the title of waste book or rough book. It was practically a business diary containing a record of operations or events, one after another in the order of their occurrence, each day's transactions being preceded by the date. The entries in the Memorial were generally in the form of brief narratives, very similar to the series of transactions we are now studying. It was but seldom that the debit and credit effect of a transaction could be seen at a glance, and this fact, joined to other considerations, revealed the need of a book which might serve as the medium for the posting of items to the ledger.

In such a book the entries would be collected from the Memorial, arranged in debit and credit form, classified under appropriate heads of account, and finally carried to the ledger. Thus, the Journal originated. By force of circumstances its authors and their immediate successors were compelled to enter separately therein each transaction recorded in the Memorial. Thus, if three debtors, P, Q, and R, happened to pay their accounts on the same day there would be three entries in the Memorial in narrative form, and three in the journal in the following form: Cash Dr. to P, Cash Dr. to Q, Cash Dr. to R.

By the time the necessity for this absolute separation of kindred items had disappeared, the custom of journalising each transaction, independently of every other, had grown into an article of faith among bookkeepers, and proposals for the condensing of entries were regarded with grave suspicion. The truth is the Venetian school have been so bedazzled with the beauty of the fundamental proposition, "for every debit there must be an equal credit," that their eyes have been blinded to the not less admirable corollary which states that the rule is satisfied if the single debit equals the sum of the several credits (and vice versâ).

Working Principle of Double Entry. For instance, if W, X, and Y pay £50 apiece on the same day, just one debit of £150 to Cash is necessary as against credits of £50 to W, £50 to X, and £50 to Y. The proof of the corollary was given in Part 4, but its overwhelming importance as the great working principle in double entry bookkeeping will be more and more appreciated by the student as his knowledge of the subject increases. The discovery and application of this simple law mark an epoch in the history of accounting, and have worked a revolution in its methods.

Breaking up the Journal. Formerly, there was but one book—the Journal—from which postings to the ledger could be made, and because the Memorial was, as its name implied, not so much an account book as a memorandum book, the Journal came to be looked upon as the real book of original or primary entry. To-day we find the Journal subdivided into day book or sales journal, invoice book or bought journal, returns inward journal, returns outward journal, and other books of primary entry with whose names and functions we shall become familiar. Cash items, once so plentiful in the Journal, are now rigorously excluded therefrom and are entered in two books specially devoted to them, which are properly cash journals, but are known as bank cash book and petty cash book. Naturally, the Journal itself was vastly reduced in bulk by the process of subdivision here described. With the exclusion of all items of purchases, sales, and returns, and the banishment of all cash items, it wasted to a mere shadow of its former self.

It cannot be denied that Continental traders generally and a respectable minority of business houses in the United Kingdom still treat the Journal with all, or almost all, the respect which it once enjoyed. The only concession they make to the modern spirit is to exclude cash and, perhaps, discount items from the Journal, entering them direct into the cash book or petty cash book as the case may be. But your time-saving bookkeeper of the present day makes his journal entries as few as possible, limiting them to such as are either opening, closing or special entries, or transfers. Just now we are concerned with the third group. Special entries go into the journal because there is no other place for them. They are mostly items of rare occurrence, items for which, in consequence, no specific book of original entry has been provided.

Record of Bill Transactions. Clearly the bill transaction referred to in (*m*) must be recorded in the journal.

JOURNAL

	Sept. 1905							
	20th							
	Henry Norgate Dr.		55	4	11			
	To Bills Payable a/c					55	4	11
	Acceptance No. 15							

By rule (*a*) [see page 491], Norgate must be debited because he receives something—*viz.*, Bevan & Kirk's acceptance, and by rule (*e*) bills payable account must be credited because the bill goes out. Notice that one money column in the journal is reserved for debits and the other for credits. The reason for this will appear in due course, but before passing on to Transaction (*o*) we must retrace our steps for a short distance.

Continued

LATIN—ENGLISH—FRENCH—GERMAN

Latin and English by G. K. Hibbert, M.A.; French by Louis A. Barbé, B.A.; German by P. G. Konody and Dr. Osten

Group 18

LANGUAGES

10

Continued from page 1344

LATIN

Continued from page 1335

By Gerald K. Hibbert, M.A.

SECTION I. GRAMMAR

Irregular Verbs : Third Conjugation

Continued

Perfect reduplicates, Supine, *-tum* or *sum*.

pendo	pependi	pensum	*weigh*
tendo	tetendi	tensum (tentum)	*stretch*
disco	didici	—	*learn*
posco	poposci	—	*demand*
curro	cucurri	cursum	*run*
pungo	pupugi	punctum	*prick*
tundo	tutudi	tunsum, *or* tusum	*thump*
fallo	fefelli	falsum	*deceive*
parco	peperci	parsum	*spare*
pario	peperi	partum	*bring forth*
cado	cecĭdi	casum	*fall*
cædo	cecīdi	cæsum	*cut, beat*
cano	cecini	cantum	*sing*
pango	pepigi	pactum	*fasten*
tango	tetigi	tactum	*touch*
pello	pepuli	pulsum	*drive*
tollo	(sustuli)	(sublatum)	*raise*

-i with lengthened stem-vowel, *-tum* (three *-sum*).

facio	feci	factum	*do, make*
jacio	jeci	jactum	*throw*
linquo	liqui	-lictum	*leave*
vinco	vici	victum	*conquer*
ago	egi	actum	*do, drive*
frango	fregi	fractum	*break*
lego	legi	lectum	*choose, read*
fugio	fugi	fugitum	*flee*
edo	edi	esum	*eat*
fodio	fodi	fossum	*dig*
fundo	fudi	fusum	*pour*
capio	cepi	captum	*take*
rumpo	rupi	ruptum	*break*
emo	emi	emptum	*buy*

B. U- VERBS.

-i, -tum.

acuo	acui	acutum	*sharpen*

Also, *arguo* (prove), *exuo* (put off), *induo* (put on), *imbuo* (tinge), *minuo* (lessen), *statuo* (set up), *tribuo* (assign). *Metuo* (fear) and *nuo* (nod) have no supine.

luo	lui	luitum, *or* lutum	*wash, atone*
ruo	rui	ruitum	*rush, fall*
solvo	solvi	solutum	*loosen*
volvo	volvi	volutum	*roll.*

DEPONENTS.

Pres.	*Infin.*	*Pf. Ptc.*	
fungor	-i	functus	*perform*
amplector	-i	amplexus	*embrace*
nitor	-i	nisus, *or* nixus	*strive*
patior	-i	passus	*suffer*
utor	-i	usus	*use*
gradior	-i	gressus	*step*
labor	-i	lapsus	*glide*
morior	-i	mortuus	*die*
queror	-i	questus	*complain*
fruor	-i	fruitus (fructus)	*enjoy*
loquor	-i	locutus	*speak*
sequor	-i	secutus	*follow*
apiscor	-i	aptus	*obtain*
comminiscor	-i	commentus	*devise*
expergiscor	-i	experrectus	*wake up*
fatiscor	-i	fessus	*grow tired*
irascor	-i	iratus	*be angry*
nanciscor	-i	nactus	*obtain*
nascor	-i	natus	*be born*
obliviscor	-i	oblitus	*forget*
paciscor	-i	pactus	*bargain*
proficiscor	-i	profectus	*set out*
ulciscor	-i	ultus	*avenge*

Irregular Verbs : Fourth Conjugation

-ui or *-ivi, -tum.*

aperio	aperui	apertum	*open*
operio	operui	opertum	*cover*
salio	salui	(saltum)	*leap*
sepelio	sepelivi	sepultum	*bury*

-i, -tum.

comperio	comperi	compertum	*find*
reperio	repperi	repertum	*discover*
venio	veni	ventum	*come*

-si, -tum (one, *-sum*).

fulcio	fulsi	fultum	*prop*
sancio	sanxi	sanctum	*consecrate*
vincio	vinxi	vinctum	*bind*
haurio	hausi	haustum	*drain*
sentio	sensi	sensum	*feel*

DEPONENTS.

assentior	-iri	assensus	*agree to*
experior	-iri	expertus	*try*
metior	-iri	mensus	*measure*
opperior	-iri	oppertus	*wait for*
ordior	-iri	orsus	*begin*
orior	-iri	ortus	*rise*

NOTE. The following verbs, while apparently of the fourth conjugation, are really third :

Capio, cupio, facio, fodio, fugio, jacio, pario, rapio, sapio, quatio, compounds of *specio* and *lacio, gradior, patior, morior* ; and in some tenses *orior* and *potior.* In their present stem forms they usually retain the *-i*, but not before *i*, final *e*, and short *er*—*e.g.*, *capiam, cape, caperc, capiendum.*

Morior and *orior* have future participles—*moriturus* and *oriturus.*

Orior is conjugated like *patior*, except a few forms which follow the fourth conjugation: *oriri, orirer*, etc. *Potior* follows the fourth, but occasionally wavers between third and fourth: *poterer* and *potirer*.

Verbs Compounded with Prepositions. Simple verbs are not so often used in Latin as verbs compounded with a preposition, the prep. either strengthening or changing the meaning. The following are the chief changes of prepositions in composition:

1. *A, ab-* become *a-* before *m, v* (*amitto, avoco*); *abs* before *c, t* (*abscedo, abstergo*); *as-* before *p* (*asporto*); *au-* before *f* (*aufero*). But *afui* (from *absum*).

2. *Ad-* becomes *a-* before *gn, sc, sp* (*ascendo, aspicio, agnosco*).

It remains *ad-* before *b, d, h, j, m, v*, and vowels, but is assimilated before other letters: *affero, assisto*.

3. *Con-* (for cum), and *in*, are written *com-, im-*, before *p, b, m* (*compello, imbuo*), but are assimilated before *l, r*: *colludo, irruo*. They remain unchanged before other consonants, except that:

Con- becomes *co-* before *h, gn*, and vowels: *coeo, cognosco*. Also, *ignosco*.

4. *Ob-, sub-*, are assimilated before *c, g, p, f*: *occurro, suffero*; except *suscipio, suscito, suspendo, suspicio*.

They remain before other letters, except *sustineo, sustollo, sustuli, surripio*.

Note omitto, ostendo.

5. *E-, ex-* are assimilated before *f*: *effero*. *Ex-* before vowels, *h, c, q, p, s, t*; *e-* before other letters: *educo, evoco*.

6. *Trans-* becomes *tra-* before *d, j, n*: *trado, trajicio, trano*.

7. *Dis-* (inseparable prefix) is assimilated before *f*: *differo*. It becomes *di-* before *s* with consonant (*distringo*) and certain consonants (*diruo*). Note *dirimo* for *disimo*.

8. *Re-, se-* (inseparable prefixes) add *d* in *reddo, redeo, redhibeo, redimo, redoleo, seditio* (noun).

In addition to the changes in the preps., there is a vowel change in the verbs themselves in becoming compounds—*e.g.*, *concutio* (*quatio*), *collido* (*lædo*), *explodo* (*plaudo*), *exigo* (*ago*), *conficio* (*facio*), *confiteor* (*fateor*), *retineo* (*teneo*), etc. The student must look these up for himself in the dictionary, as he comes across them in his reading.

SECTION II. SYNTAX

Questions to which an affirmative answer is expected are introduced in Latin by *nonne*.

When a negative answer is expected, by *num*.

When the answer is absolutely an open matter, by the enclitic *-ne* added usually to the first word of the sentence—*e.g.*,

Num putas bis bina esse quinque? = you surely don't think that twice two are five, do you?

Nonne Cæsar erat imperator maximus = was not Cæsar a mighty general?

Putasne me patris similem esse = do you think that I am like my father?

The above are all *direct questions*. In *indirect questions*—*i.e.*, questions depending on a verb—the verb in the question is subjunctive. "Whether" and "if" in such sentences are rendered by (1) *utrum*, followed by *an* or *ne*; (2) *num*—*e.g.*, *Rogavit utrum hæc vera essent annon* = he asked whether this was true or not.

NOTE. Distinguish between "whether" thus introducing a dependent clause, and "whether" used to express a condition; the latter is *sive*, a compound of *si* = if—*e.g.*:

Hæc, sive vera sunt sive falsa, nullo modo me movent = whether—*i.e.*, if—this is true or false I am not troubled by it.

IDIOMATIC SENTENCES TO BE PUT INTO LATIN.

1. Socrates was called to trial on the charge of corrupting the youth, but in reality because he had become suspected by those in power.

2. He is too wise to err, too good to be unkind.

3. He came to such a pitch of folly that he could not be persuaded to eat.

4. It was resolved to send ambassadors to ask what was the meaning of these repeated insults.

5. I hear that she died four years after returning home: I fear that her children are in very poor circumstances.

6. If you help me, I shall rejoice; if not, I shall not take it ill.

7. The enemy at once sounded a retreat. When he heard this, the general bade his men also retire.

8. I came to see you at once, inasmuch as I had received many kindnesses at your hands.

9. Although he was the first to leave the ship, he is not the man to be a coward.

10. I am different from what I once was; so it is absolutely necessary for me to remain at home for several days.

LATIN VERSION OF THE ABOVE.

1. Socrates in judicium vocatus est quod corrumperet juventutem, re tamen ipsa quia in suspicionem magistratibus venerat.

2. Sapientior est quam qui erret, melior quam qui inclementer agat.

3. Eo stultitiæ venit ut illi non persuaderi posset ut ederet.

4. Placuit legatos mitti qui rogarent quid vellent hæ tot contumeliæ.

5. Nuntiatum est mihi illam anno quarto postquam domum rediisset mortuam esse: cujus liberi timeo ne pauperrimi sint.

6. Si mihi subvenies (*note tense*), gaudebo: sin minus, haud ægre feram.

7. Hostes confestim receptui canunt. Quod quum audivisset imperator, suis quoque ut recedant imperat (*historic present*).

8. Statim veni te visum, ut qui multa beneficia a te accepissem.

9. Quamvis primus navem reliquerit, non is est qui ignave fugiat.

10. Alius sum atque olim fui: itaque me oportet plures dies domi manere.

SECTION III. TRANSLATION.

THE GREAT ERUPTION OF VESUVIUS.

August 24th, A.D. 79.

Extract from letter of Pliny the Younger to Tacitus.

Nec multo post illa nubes descendere in terras, operire maria. Cinxerat Capreas et absconderat: Miseni quod procurrit, abstulerat. Tum mater orare, hortari, jubere, quoquo modo fugerem; posse enim juvenem: se et annis et corpore gravem bene morituram, si mihi causa mortis non fuisset. Ego contra, salvum me, nisi una, non futurum: dein manum ejus amplexus, addere gradum cogo. Paret ægre, incusatque se, quod me moretur; jam cinis, adhuc tamen rarus. Respicio; densa caligo tergis imminebat, quæ nos, torrentis modo infusa terræ, sequebatur. Deflectamus, inquam, dum videmus, ne in via strati comitantium turba in tenebris obteramur. Vix consederamus, et nox, non qualis illunis aut nubila, sed qualis in locis clausis lumine exstincto. Audires ululatus feminarum, infantium quiritatus, clamores virorum. Alii parentes, alii liberos, alii conjuges vocibus requirebant, vocibus noscitabant. Hi suum casum, illi suorum miserabantur. Erant qui metu mortis mortem precarentur. Multi ad deos manus tollere: plures, nusquam jam deos ullos, æternamque illam et novissimam noctem mundo interpretabantur.

ENGLISH VERSION OF ABOVE.

Not long afterwards that cloud descended (*historic infinitive*) over the land and covered the sea. It had encircled Capreæ and blotted it out: it had removed from our sight the promontory of Misenum. Then my mother begged, exhorted, ordered me to flee in whatever way I might, (saying) that a young man could, and that she, weighed down with years and weakness of body, would die happy, if she had not been the cause of my death. I on the other hand (affirm) that I will not be saved unless with her: then clasping her hand, I urge her to quicken her step. She obeys reluctantly, and blames herself for delaying me. Now there are ashes, as yet, however, few and far between. I look back; thick darkness overhung us in the rear, and kept following us, pouring over the land like a flood. "Let us turn aside," I say, "while we can see, lest being knocked down in the street we be trampled upon in the darkness by the crowd of our companions." Scarcely had we sat down when night (was upon us), not a mere moonless, cloudy night, but such night as there is in a closed room when the light is extinguished. You could hear the wailing of women, the cries of infants, the shouts of men. Some were seeking by the voice, by the voice were recognising parents, others children, others wives. These were pitying their own fate, those that of their loved ones. There were some who, through the fear of death, prayed for death. Many raised their hands to the gods: while more still imagined that there were no longer any gods anywhere, and that this was the final and everlasting night for the world.

[This is a more or less literal translation, given in order to enable the student to make out the meaning of the Latin. He should not, however, rest content with merely translating Latin literally into English, but should polish and re-polish his English version until it reads well and smoothly. For models of translation see "Translations," by Jebb, Jackson, and Currey, published by Bell & Sons.]

Continued

ENGLISH

Continued from page 1338

By Gerald K. Hibbert, M.A.

PUNCTUATION—*Continued*

Other stops are:

The *note of interrogation* (?), placed at the end of all direct questions—as: "Who is there?" It is not used after an indirect or reported question—as: "He asked who was there."

The *note of exclamation* (!), used after interjections and exclamations; also usually after the Vocative Case—as: "All hail, great master!" "Alas!"

Curved and square brackets, ( ), [ ], used to separate certain words from the rest of the sentence, to add an explanation of a difficult word, etc.

Inverted commas, double "—", or single —', used to mark quotations. When a quotation occurs within a quotation, the inner quotation is generally marked by single inverted commas—as:

> "Breathes there the man with soul so dead,
> Who never to himself hath said,
> 'This is my own, my native land'?"

EXERCISE.

Punctuate the following passage from one of Hans Andersen's Fairy Tales:

"A whiptop and a little ball were together in a drawer among some other toys and the top said to the ball shall we not be bridegroom and bride as we live together in the same box but the ball which had a coat of morocco leather and was just as conceited as any fine lady would make no answer to such a proposal next day the little boy came to whom the toys belonged he painted the top red and yellow and hammered a brass nail into it and it looked splendid when the top turned round look at me he cried to the ball what do you say now shall we not be engaged to each other we suit one another so well you jump and I dance no one could be happier than we two should be indeed do you think so replied the little ball perhaps you do not know my papa and mamma were morocco slippers and that I have a Spanish cork inside me yes but I am made of mahogany said the top and the mayor himself turned me he has a turning lathe of his own and it amuses him greatly can I depend upon that asked the little ball may I never be whipped again if it is not true replied the top."

Correct the punctuation of the following passage, which is altered from one of Thomas Fuller's "Mixt Contemplations on these Times":

"In the year of our Lord, 1606, there happened a sad overflowing of the Severn-sea. On both sides thereof which, some still alive one I hope thankfully remember? An account, hereof was written to John Stow the industrious chronicler from Dr. Still: then bishop of Bath and Wells and three other gentlemen of credit to insert in his story one passage, wherein I cannot omit! 'Stow's Chronicle' p; 889 Among other things of note it happened that upon the tops of some hills divers, beasts of contrary nature had got up for their safety as dogs. Cats foxes hares conies moles mice; and rats who remained together? Very peaceably without any manner or sign, of fear of violence one towards another? How much of man was there, then, in brute creatures. How much of brutishness is there now in men. Is this a time for those? Who are sinking for the same cause! To quarrel and fall out: I dare add no more: but the words of the Apostle 2 Tim. ii. 7. Consider what? I say and the Lord give you, understanding, in all things."

STYLE

The main object of our study of the English language is that we may be able to express ourselves clearly in it, whether in writing or in speech. We must aim not only at meaning exactly what we say, but also at saying exactly what we mean. It is not enough to have our own thoughts and ideas perfectly plain to ourselves; for unless we can convey them clearly to other people, mistakes occur, misunderstandings arise, feelings are often wounded unnecessarily, and mischief frequently follows.

Absolute clearness of style is the result of long and careful discipline, but it is a result that will well repay the labour. It can be cultivated better in writing than in speech, because we can revise what we have written, whereas the spoken word is usually forgotten as soon as uttered. We should therefore make it a practice at first to read and re-read everything that we write, looking carefully for any ambiguity or any loophole for misunderstanding. We may be certain that if a thing is not quite clear to the writer of it, the chances are that it will be very far from clear to anyone else.

Perhaps in no matter is this more important than in one where it is as a rule most neglected—*viz.*, that of writing business letters. It would be interesting to know the time that has been lost and the money that has been wasted simply through confusion and clumsiness of expression in the letters of our large business firms. So far from being a matter of theory, to be indulged in merely by pedantic grammarians, the necessity for a clear style is a very practical matter indeed, as thousands of people have too late found out to their cost.

Then, when clearness of expression in writing has been cultivated, clearness of expression in speech will follow as a matter of course. Have you ever noticed the different manner in which the same event will be described by a man of education and by an unlettered person? The former in a few bold strokes will give you in two minutes a clear impression of what he has seen; the latter, however, will take at least five times as long, owing to his frequent repetitions and his hunting about for words to convey his meaning, and at the close your impression of the event is still dim and hazy.

How Not to Write a Letter. As an example of what has been said above, let us take the following letter, written *first* as it should not be written—but too often, alas! is; and *secondly* as it should be written. There is no exaggeration here; thousands of similar letters are being written every day.

Letter from a young man applying for the post of cashier in a large business house:

[The letters in brackets refer to the notes on the next page].

Dear Sirs, I have read your advertisement for a cashier in the "——— Gazette" of yesterday's date, which (*a*) I have only just seen, and which (*a*) I have great pleasure in applying for, as I feel to have all the necessary (*b*) qualifications which you require (*b*). If you will write to Messrs. White & Co., I have been (*c*) with them three years, before which I was at Brownlove's, Birmingham, where I was for nearly five years under-cashier, as the testimonials from that firm which (*d*) I gave satisfaction to, and which (*d*) I enclose herewith will show. Leaving them through no fault of my own, you (*e*) will see I have had eight years experience and good character, and while (*f*) I have never been a single penny wrong in my accounts, thousands of pounds every week have passed through my hands, not only in wages, but having (*g*) to negotiate delicate matters for the firm which (*h*) needed careful handling. My age is 31 years old (*i*), although I am not married, and I may say I am a non-smoker, but steady in my habits, and know shorthand. I should have liked to have stayed (*k*) on in my present situation for some things; but without (*l*) I will accept a lower salary, the firm is reducing the staff owing to some cause or another (*m*), which (*n*) I do not see my way to do. While (*o*) I should require a salary of £180, I do not want to be excessive, and should be prepared to entertain your offer as a firm (*p*) of first-rate standing in the business world, and that (*q*) you do not under-pay your servants. Had I have (*r*) seen your advertisement sooner, I would have answered it before, as I said at the beginning (*s*), and trust I am not too late now, which (*t*) is the moment I have seen it. Hoping this will merit your favourable attention when you read it, and trusting to hear further from you when I should be delighted to have an interview when and where desired.

Believe (*v*) me, Dear Sirs,
Your obedient servant,
X. Y. Z.

The letter is not entirely ungrammatical, though its grammar is at fault in some places; but it is a fair example of a confused slipshod style, common enough in those who have never trained themselves to think or write clearly. The faults contained in it are almost too many to mention, but let us notice some of them:

a. The first *which* refers to "Gazette" the second to no particular antecedent, but to some word like "situation," which is vaguely in the writer's mind.

b. Having said *necessary*, he has no need to add "which you require." These words are redundant.

c. The subject of this second half of the *if* clause should be *you*, not *I*: "If you will write . . . you will find that I was," etc.

d. Here, again, *which* refers to two different antecedents, *firm* and *testimonials*, thus causing confusion.

e. The writer having begun with a participle, *leaving*, referring to himself, the subject of the main sentence should be "I," not "you." It was not "you" who were leaving, but "I."

f. This is an example of misplaced emphasis. He means "Although thousands of pounds have passed through my hands every week, I have never been a single penny wrong in my accounts."

g. Hopelessly mixed. Where is there a noun with which the participle *having* can agree?

h. What is the antecedent of *which?* Was it the firm or the delicate matters that needed careful handling?

i. *Old* should be omitted. In the rest of this sentence the emphasis is hopelessly wrong; *although* and *but* give a false contrast, and what has a knowledge of shorthand to do with steadiness of habits?

k. Should be "to stay on."

l. Use the conjunction "unless" instead of "without."

m. Say either "some cause or other," or "one cause or another."

n. To what does *which* refer?

o. Wrong emphasis again; see *f* above.

p. Should be "as being that of a firm."

q. The writer makes *that* depend on some verb like "knowing," which he has vaguely in his mind.

r. "Have" should be omitted.

s. He is here needlessly repeating himself, and also irritating the reader, presuming the reader to have read so far, which is doubtful!

t. A relative pronoun should not refer to an adverb, such as *now*.

v. The writer having used two participles, *hoping* and *trusting*, both referring to himself, the subject of the main verb of the sentence should have been "I," not "you" (which is the understood subject of *believe*). He should have said, "I remain," etc.

These are a few of the details in which the letter is wrong. But in addition the sentences are far too long and involved, and the whole method of expression clumsy and cumbersome in the extreme.

Same Letter Re-written. Contrast the above letter with the following version of the same:

Dear Sirs,—I have only just seen your advertisement in the "—— Gazette" of yesterday's date, and hasten to apply for the post of cashier there advertised as vacant. I have been three years with my present employers, Messrs. White & Co., and before that I was under-cashier at Brownlove's, Birmingham, for nearly five years. I enclose herewith testimonials from the latter firm. My present employers kindly allow me to give you their names for reference. I have thus had eight years' experience of the class of work required. Thousands of pounds have passed through my hands every week, and I have often had to negotiate delicate matters of business for the firm. I am 31 years old, unmarried, and of steady habits. I have also a knowledge of shorthand. My present employers are reducing their staff owing to various reasons, but have asked me to stay on in their employ. As, however, they are not prepared to offer me as high a salary as in the past, I have decided to leave. I should require a salary of £180 per annum; but if that is a higher figure than you are prepared to offer, I shall be glad to hear what you propose. I would leave myself largely in your hands in this matter. I shall be pleased to let you have any further information you may require, or to have an interview with you if you so desire. Trusting that my application is not too late,

I remain, dear sirs, etc.

Chief Errors of Style. It is impossible to mention all the errors of style that can be committed, but the following are the most common. A good many of them will be found to have been exemplified in the letter given above.

1. Irrelative Use of Words. Words are often left without any relation whatever Examples:

"Your guilt is as great or greater than his," where *as* has nothing to which to relate.

"He is not only acquainted, but well versed in English literature," where *acquainted* should be followed by *with*, to bring it into relation with the rest of the sentence.

"Having crossed the stream, the banks on either side fell in," where *having crossed* has no relation to any other word of the sentence. As it stands, it agrees with *banks*; but the banks did not cross the river.

"Alarmed at the appearance of the sky, a terrific peal of thunder shook the house, so that he ran out," where *alarmed* is not related to any other word. Grammatically, it agrees with *peal of thunder*, but it was not the peal of thunder that was alarmed. The subject of the main sentence should, of course, be *he*.

Such errors as these are usually due to forgetfulness or a sudden change of mind on the part of the writer or speaker. In the following sentence, for example, "I would as soon perish in the lowest depths of the sea—yea, die the most degrading death that is possible to man or woman, beast or brute, than I would accept life on the terms you offer," the writer forgets that he has started with " as soon," and imagines that he has said, " I would *rather* perish." Hence, the use of *than*. There is need of great care to avoid errors like these, especially in long and involved sentences.

2. Wrong Order. Many errors arise from a wrong or misleading *order* of words.

As a rule, a sentence should run in its natural order: Subject (and its limitations), predicate, object (and its limitations), adverbial limitations of the predicate—as: " The dying hero spoke words of consolation and of cheer in the midst of his mortal agony." For the sake of emphasis, or for certain other reasons, the order may be altered. But whatever be the order, the important point is that the meaning shall be clear.

Great care is needed in dealing with relative pronouns, lest they seem to refer to a substantive which is not intended to be their antecedent. For example: " He threw a pint pot at her head, which smashed into a thousand pieces." " Much energy was displayed by Mr. Smith in running down the street after his silk hat, which he felt might have been devoted to a better purpose." The only way of avoiding this pitfall is to place the antecedent *immediately* before the relative—thus: " He threw at her head a pint pot," etc. " Mr. Smith, in running down the street after his silk hat, displayed an amount of energy," etc.

Equal care is necessary in dealing with adverbs or adverbial phrases, as these have an awkward knack of appearing to qualify words which they are not intended to qualify. The following examples are among those given by Dr. Gow in his book, " A Method of English ":

" He blew out his brains after bidding his wife good-bye with a gun."

" The Moor seizing a bolster full of rage and jealousy smothers her."

" Erected to the memory of John Phillip accidentally shot as a mark of affection by his brother."

" He was driving away from the church where he had been married in a coach-and-six."

" The young man coloured with pleasure and promised to return in quite a gratified tone of voice."

3. Misplacement of Emphasis. In a complex sentence, errors often arise through misplacement of emphasis. A sentence which ought to be independent and stand alone is sometimes thrown into the form of a subordinate clause. It thereby loses the emphasis that should attach to it. This is especially the case with relative pronouns and adverbs. For example, the full force of " He called me a liar, and then I struck him " is not adequately represented by " He called me a liar, when I struck him." Similarly, with " I have said it, and I will do it," and " I have said it, which I will do."

Two co-ordinate sentences, each of which ought to stand alone, cannot be thrown into the form of a single complex sentence (one of the two becoming a subordinate clause) without loss of meaning. Thus, " Ink, having a bitter taste, makes a mark on paper " is not a good substitute for " Ink has a bitter taste: it also makes a mark on paper "; for its making a mark on paper is not a consequence of its having a bitter taste.

For clearness of style and simplicity of language the Authorised Version of the English Bible is hard to beat. Next to that, perhaps, a study of Ruskin's writings will give one an idea of beauty and simplicity of style. Let a man read nothing but these for three months, and he will find his style growing simpler and clearer, and at the same time more dignified. When he is well saturated with their spirit, he can turn without harm to exponents of other styles. He can read Carlyle without falling into his faults, and can pass unscathed through the most flowery and ornate sentences of the late Dean Farrar. But each man has a style of his own for which he is adapted by nature. Therefore let his study of the great stylists be rather for the perfecting of his own particular gift than with the idea of slavishly imitating another's.

READING ALOUD

Reading aloud seems to be almost a forgotten art. Our grandfathers and grandmothers were adepts at it; but as it is a process that takes some time, it does not appeal to the present generation. Even our public readers, such as the clergy and ministers of all denominations, seem to think that anything will do in this connection. With few exceptions, the occupiers of our pulpits are utterly incompetent readers. It is, however, an art that is well worth cultivating. It can give great pleasure, it can become one of the most potent educational agencies in the world, and—to put it on its lowest level—it may help one very materially to benefit his position in life.

Clearness is here, as in style, the main object. We need first to grasp the writer's meaning, and then to convey that meaning as adequately as possible to others. Hurry is fatal to reading aloud. A passage that is gabbled over loses its intelligibility for the hearers. Emphasis is also a most important point, a whole passage being often " murdered " by a mistake in this respect. Finally, we must strive to avoid monotony; nothing is more dreary than to listen to a reader who ends every sentence in exactly the same key. If anyone wants an agonising example of this, let him listen to a bad reader reading one of the longest psalms in the Psalter. The inflection of the voice should be carefully studied, so as to give as much variety and life as possible to the subject-matter.

Value of Emphasis. Most people when asked if they can read aloud will promptly answer " Yes." Let us take warning from the fate of a young American student in the theological seminary at Andover. History relates that he had an excellent opinion of his own talent in elocution, and that he once asked his professor, " What do I specially need to learn in this department ? "

" You ought just to learn to read," said the professor.

" Oh, I can read now!" replied the student.

The professor handed him a New Testament, and asked him to read St. Luke xxiv. 25. The student read, "Then he said unto them, O fools, and slow of heart to *believe* all that the prophets have spoken."

"Ah," said the professor, "they were fools for *believing* the prophets, were they ?"

That was not right; so the young man tried again.

"O fools, and slow of heart to believe *all* that the prophets have spoken."

"The prophets then were sometimes liars ?" asked the professor.

"No. O fools, and slow of heart to believe all that the *prophets* have spoken."

"According to this reading," the professor suggested, "the prophets were notorious liars."

This was not a satisfactory conclusion; and so another trial was made.

"O fools, and slow of heart to believe all that the prophets have *spoken*."

"I see now," said the professor; "the prophets wrote the truth, but they *spoke falsehoods*."

[Quoted by W. H. Groser in his "Teacher's Manual."]

Surely it is worth an effort to become good readers. Ten minutes a day spent in careful deliberate reading aloud would soon make a great difference in the delivery of the average person.

Continued

FRENCH

Continued from page 1341

By Louis A. Barbé, B.A.

DEMONSTRATIVE ADJECTIVES

The demonstrative adjectives are: *ce, cet, cette*, this or that; *ces*, these or those.

Ce, this, that, is used before a masculine singular noun, beginning with a consonant or aspirated *h*: *ce village*, this village; *ce hameau*, that hamlet.

Cet, this, that, is used before a masculine singular noun beginning with a vowel or silent *h*: *cet arbre*, this tree; *cet habit*, that coat.

Cette, this, that, is used before any feminine singular noun: *cette pelouse*, this lawn; *cette auberge*, that inn; *cette herbe*, that grass; *cette harpe*, that harp.

Ces, these, those, is used before all plural nouns: *ces villages, ces hameaux, ces arbres, ces habits, ces pelouses, ces auberges*.

There may be qualifying adjectives between the demonstrative and the noun: *ce petit village, ce grand arbre, cette vieille maison, ces belles fleurs*.

Of themselves, the demonstrative adjectives mean both "this" and "that," in the singular, and both "these" and "those" in the plural.

When it is required to distinguish between nearer and more remote objects, *ci* (= *ici*, here), and *là* (there), are respectively placed after the noun, and joined to it by a hyphen: *ce bijou-ci est plus précieux que ce bijou-là*, this jewel is more valuable than that jewel; *ces tableaux-ci sont plus beaux que ces tableaux-là*, these pictures are finer than those pictures.

POSSESSIVE ADJECTIVES

The possessive adjectives are:

	Masculine.	Feminine.	Plural.
My	*mon*	*ma*	*mes*
Thy	*ton*	*ta*	*tes*
His and Her	*son*	*sa*	*ses*
Our	*notre*	*notre*	*nos*
Your	*votre*	*votre*	*vos*
Their	*leur*	*leur*	*leurs*

2. Possessives agree, not with the possessor, as in English, but with that which is possessed, thus: *mon père*, my father; *ma mère*, my mother; *mes enfants*, my children. Consequently, *son père*, means both his father and her father; *sa mère*, his mother and her mother; *ses enfants*, his children and her children.

3. *Mon, ton, son* are not always masculine. They are also used instead of *ma, ta, sa* before feminine words beginning with a vowel or silent *h*, thus: *ignorance, erreur*, and *histoire* are feminine, but we say *mon ignorance, ton erreur, son histoire*.

4. When, from the other words in the sentence, there can be no doubt as to the possessor, the definitive article is used instead of the possessive pronoun. This is particularly the case with regard to parts of the body: *J'ai mal à la tête*, I have a headache; *liez-lui les mains derrière le dos*, tie his hands (*lit.* to him the hands) behind his (the) back.

5. The use of the definite article instead of the possessive adjective is very general in descriptions of personal appearance. Possession is then expressed by means of the verb *avoir*: His hair is black, *il a les cheveux noirs*; her eyes are blue, *Elle a les yeux bleus*.

Exercise X

1. There are no large houses in that village.
2. Those large trees are oaks (*chênes*).
3. These children are the sons of that barrister.
4. This house is older than that house.
5. That child is the most industrious (*appliqué*), pupil in the class.
6. Have you spoken to that gentleman and to those ladies ?
7. Why (*pourquoi*) have you put (*mis*) my books on that table ?
8. Your brother has bought those horses.
9. This little boy and that little girl are very amiable.
10. I have not yet (*encore*) read (*lu*) those papers (*journal*).
11. When (*quand*) those children are well-behaved (*sage*) their mother is happy (*heureux*).
12. Our parents are our best friends.
13. That young lady has black hair and blue eyes.
14. The boy speaks to his mother, and his sister speaks to her father.

COMPOUND TENSES

The past indefinite (*passé indéfini*) of verbs (usually called perfect in English) is formed by adding the past participle (*participe passé*) to the present indicative of *avoir*, to have.

The past participle of *avoir* is *eu*.

The past participle of *être* is *été*.

The past participle of verbs of the first conjugation (verbs ending in *er* in the infinitive) always ends in *é*, thus: *aimer*, to love, *aimé*, loved; *donner*, to give, *donné*, given.

Tenses which, like the past indefinite, consist of an auxiliary and a past participle, are called compound tenses.

Past Indefinite of AVOIR:	Past Indefinite of ÊTRE:
I have had, etc.	I have been, etc.
j'ai eu	*j'ai été*
tu as eu	*tu as été*
il a eu	*il a été*
elle a eu	*elle a été*
nous avons eu	*nous avons été*
vous avez eu	*vous avez été*
ils ont eu	*ils ont été*
elles ont eu	*elles ont été*

Past Indefinite of AIMER:

I have loved, etc.
j'ai aimé
tu as aimé
il a aimé
elle a aimé
nous avons aimé
vous avez aimé
ils ont aimé
elles ont aimé

In compound tenses in which *avoir* is the auxiliary verb, the past participle does not agree with the subject.

In compound tenses the negation is formed by putting *ne* (*n'*) between the subject and the auxiliary, and *pas* between the auxiliary and the past participle.

Past Indefinite Conjugated Negatively:

AVOIR.	ÊTRE.
I have not had, etc.	I have not been, etc.
je n'ai pas eu	*je n'ai pas été*
tu n'as pas eu	*tu n'as pas été*
il n'a pas eu	*il n'a pas été*
elle n'a pas eu	*elle n'a pas été*
nous n'avons pas eu	*nous n'avons pas été*
vous n'avez pas eu	*vous n'avez pas été*
ils n'ont pas eu	*ils n'ont pas été*
elles n'ont pas eu	*elles n'ont pas été*

AIMER.

I have not loved.
je n'ai pas aimé
tu n'as pas aimé
il n'a pas aimé
elle n'a pas aimé
nous n'avons pas aimé
vous n'avez pas aimé
ils n'ont pas aimé
elles n'ont pas aimé

NEGATIVE EXPRESSIONS

The expressions with which a verb may be conjugated negatively are:

ne . . . pas, not
ne . . . point, not (stronger than *ne . . . pas*)
ne . . . que, only, nothing but
ne . . plus, no more, no longer
ne . . jamais, never
ne . . . guère, not much, hardly
ne . . . personne, nobody
ne . . . rien, nothing

Thus:

Il n'a pas de livres, he has no books.
Il n'a pas eu de peine, he has had no trouble.
Il n'a point d'argent, he has no money at all.
Il n'a plus parlé, he spoke no more.
Il ne parle guère, he does not speak much.
Il ne lit jamais, he never reads.
Il n'a jamais lu, he has never read.

When "nobody" and "nothing" are the objects of a verb, *ne* precedes the verb and *personne* or *rien* follows it:

je ne vois personne, I see nobody.

But, with compound tenses, whilst *rien* comes between the auxiliary and the past participle, according to rule, *personne* comes after both auxiliary and past participle:

je n'ai rien vu, I have seen nothing.
je n'ai vu personne, I have seen nobody.

When "nobody" and "nothing" are subjects of a verb, their place is before both *ne* and the verb:

personne ne parle, nobody speaks.
rien n'empêche, nothing prevents.

When any of these negations are used without a verb there is no *ne*: Who has spoken? Nobody. *Qui a parlé? Personne.*

In *ne . . . que*, the *que* comes after the verb in both simple and compound tenses:

Je ne vois que votre frère, I see only your brother; *je n'ai vu que votre frère*, I have seen only your brother. *Ne . . . que* does not prevent the use of the article as well as *de* to express the partitive meaning, as do the other negatives: *je n'ai vu que des arbres*, I have seen nothing but trees.

NOTE. In the following exercise special attention must be paid to the use of the definite and of the partitive articles, as explained in the earlier lessons.

EXERCISE XI

RECAPITULATORY

une amande	almond
un âne	ass
un animal	animal
le bœuf	ox
le bois	wood
le chacal	jackal
le champ	field
la chèvre	goat
le chien	dog
le corps	body
un écureuil	squirrel
une espèce	species, kind
une étoile	star
un être	being
le gland	acorn
une histoire	history
un intérieur	interior
le lièvre	the hare
le lion	the lion
le loup	wolf
le minéral	mineral
le métal	metal
la noisette	hazel-nut
un oiseau	bird
une oreille	ear
la plante	plant
le poil	hair (of animals)
le règne	kingdom (of Nature)
le renard	fox
le tigre	tiger
la variété	variety
le végétal	vegetable

agile, active
ardent, mettlesome, spirited
bon, good, kind, gentle
capricieux, capricious, frisky
courageux, courageous
court, short
cruel, cruel
docile, docile
domestique, domestic
féroce, ferocious, savage
fier, proud
fort, strong
fougueux, fiery
impétueux, impetuous
intéressant, interesting
léger, light, swift
long, long
naturel, natural
nerveux, vigorous
nombreux, numerous
nuisible, injurious, hurtful
patient, patient
robuste, hardy
rude, rough, coarse
sauvage, wild
sobre, temperate
timide, timid
tranquille, quiet
vagabond, fond of wandering
végétal, vegetable
vif, quick
vivant, living

composer, to compose
étudier, to study
manger, to eat
semer, to scatter
passer, to pass

comme, as, like
extrêmement, exceedingly
fort, very
très, very
ou, or

Natural history studies plants, minerals and animals. Plants or vegetables compose the vegetable kingdom. Plants are scattered on the earth like stars in the heavens. Minerals are bodies in the interior of the earth. Metals are minerals. In the natural history of animals an infinite variety of living beings pass before our eyes. The species of animals are more numerous than the species of plants. The animals the most useful to men are domestic animals. Amongst the domestic animals are horses, asses, oxen, cows, sheep and goats. Horses are proud and spirited, but they are as docile as courageous. Horses are more elegant than asses and than oxen. Their ears are less long than the ears of asses. They are not so short as the ears of oxen. There are wild horses. They are stronger, swifter, more vigorous than domestic horses, but they are less useful. Asses are gentle, temperate, and useful. They are as patient and as quiet as horses are proud, fiery and impetuous. Dogs also are domestic animals. There are wild dogs, but they are savage. They are as savage as wolves and as jackals. Goats are not so useful to men as sheep, but they are very useful. Their hair is rougher than the wool of sheep. They are stronger, lighter, more active than sheep. They are lively, hardy, frisky, and fond of wandering. Amongst wild animals, lions and tigers are the most savage and the most cruel. Foxes are wild also, but they are not so savage as tigers. They are less savage than jackals. Hares are wild, but they are not hurtful. They are exceedingly timid. Squirrels also are very timid little animals. They are very pretty and very interesting. They eat fruits, almonds, walnuts and acorns. There are no squirrels in the fields. They are in the woods on trees, like birds.

KEY TO EXERCISE VIII. [page 1339]

1. La sœur du jeune homme a de gentils petits enfants.
2. Les vieilles maisons ont de grands jardins.
3. Le mois de décembre est le dernier mois de l'année.
4. Il a acheté un vilain gros chien la semaine dernière.
5. Ils demeurent dans une grande maison blanche près du château ruiné.
6. Il y a deux tables rondes dans la petite chambre carrée.
7. Avez-vous de l'encre rouge ?
8. Non, mais j'ai de l'encre noire et de l'encre bleue.
9. La langue française est une langue romane.
10. L'Espagne est un pays catholique ; l'Angleterre et l'Ecosse sont des pays protestants.
11. L'enfant prit l'argent d'une main tremblante.
12. La vieille église est près du parc public.
13. Le pasteur français est un homme très intelligent et très instruit.
14. Il n'y a pas de remèdes infaillibles.
15. Un brave homme n'est pas toujours un homme brave.
16. Un homme riche peut être un pauvre homme.
17. Un fossé large et profond défend l'approche du vieux château.
18. Paris est une grande et belle ville.
19. Ils ont rencontré des difficultés insurmontables.
20. Nous avons parlé à un jeune homme très aimable.

KEY TO EXERCISE IX. [page 1340]

1. Le cheval est plus grand que l'âne, aussi grand que le bœuf et moins grand que l'éléphant.
2. Les chats ne sont pas si fidèles que les chiens.
3. Le tigre est le plus féroce des animaux.
4. Mes plus beaux tableaux et mes meilleurs livres ne sont pas ici.
5. Voici le mieux connu des romans de Dumas.
6. Il demeure dans la plus petite maison du village.
7. La moindre difficulté décourage les élèves paresseux.
8. Il a passé plus de trois mois en France.
9. Trois chats mangent moins que deux chiens.
10. Le loup a mangé plus de trois brebis.
11. L'or est moins utile que le fer ; l'or est le plus précieux, mais le fer est le plus utile des métaux.
12. La montagne la plus élevée de l'Écosse a plus de quatre mille pieds.
13. Voilà un des élèves les plus intelligents de la classe.
14. La plus jolie des deux sœurs n'est pas la plus aimable.
15. Les fruits les plus amers sont souvent les plus sains.
16. Le remède est souvent pire que le mal.
17. Les médecins sont plus utiles que les avocats.
18. On a souvent besoin d'un plus petit que soi.

Continued

GERMAN

Continued from page 1344

By P. G. Konody and Dr. Osten

XVIII. In the STRONG CONJUGATION OF VERBS [see X.] the characteristic features are the formation of the *imperfect* by *changing the stem-vowel* and of the *past participle* by the suffix -en or -n with or without change of the stem-vowel, and with or without the prefix ge- [see XIV.]. The stem-vowel is also changed or modified in some cases of the *present indicative* and in the *imperfect conjunctive.*

1. The *present tense* of the verb ſchreiben, to write, may serve as example for the inflections of the strong verb.

		Indicative		*Conjunctive*
Sing.	1.	ich ſchreib-e	I write	ich ſchreib-e
	2.	du ſchreib (e)ſt	thou writest	du ſchreib-eſt
	3.	er ſchreib-(e)t	he writes	er ſchreib-e
Plur.	1.	wir ſchreib-en	we write	wir ſchreib-en
	2.	ihr ſchreib-et	you write	ihr ſchreib-et
	3.	ſie ſchreib-en	they write	ſie ſchreib-en

In the conjunctive the flective e can never be dropped; it is also better to retain it in the second person indicative of verbs with stems ending in hissing sounds: s, ſſ, ſch, z, where the omission would cause harshness—for instance: du ſchieß-eſt, thou shootest etc. In some of these verbs *both* forms are used, as: 1. ich vergeſſe, I forget; 2. du vergiſſ-eſt and du vergiß-t, etc.

2. The majority of verbs with the stem-vowel a, au, and some with o (*a*) modify it, and others (*b*) change the stem-vowel e into i or ie in the second and third person singular of the indicative, and cast off the flective e.

EXAMPLES: (*a*) 1. ich grabe, I dig; 2. du gräbſt; 3. er gräbt. 1. ich fange, I catch; 2. du fängſt; 3. er fängt. 1. ich laufe, I run; 2. du läufſt; 3. er läuft, etc. (*b*) 1. ich fechte, I fence; 2. du fichſt; 3. er ficht. 1. ich gebe, I give; 2. du giebſt; 3. er giebt. (The conjunctive remains unaltered: 1. ich grabe; 2. du grabeſt; 3. er grabe, etc.)

3. Several of the verbs mentioned in 2, with stems ending in t, th, and d, drop not only the flective e, but also the t of the inflection of the third person singular indicative: 1. ich rathe, I advise; 2. du rath(e)ſt; 3. er räth, etc.

4. The *imperative* of the *strong verbs* is formed as in the weak conjugation [see XIV. 3]: 2nd per. sing. bleib(e)! stay, remain! 2nd per. sing. ſchreib! write! Civil address: bleiben Sie! stay! ſchreiben Sie! write!

The verbs with the stem-vowel e change it in the singular into i or ie without suffix: fecht-en, to fence, ficht! geb-en, to give, gieb! eſſ-en, to eat, iß! etc. The circumscribed forms of the imperative are formed as in the weak conjugation [see XIV. 4, 5].

XIX. The IMPERFECT INDICATIVE of the strong verbs is formed by changing the vowel in all persons and numbers; a further change of the *changed* vowel takes place in the past participle. The third person singular of the imperfect indicative takes no inflection, and the second person takes the inflection -eſt after hissing sounds) or ſt: blaſ-en, to blow, 2nd pers. sing. du blieſ-eſt, thou blewest; but: bleib-en, 2nd pers. sing. du blieb-ſt. The inflections of the plural (1. -en, 2. -et, 3. -en) are to be seen below in the conjugation of the imperfect of ſing-en, to sing, which belongs to the group of verbs that change their vowel -i- in the imperfect into -a-, and change it further into -u- in the past participle with the suffix -en and the usual prefix ge-. The present, imperfect, and past participle of ſingen are: *pres.*: (ich) ſing-e; *imp.*: (ich) ſang; *p. past*: ge-ſung-en.

IMPERFECT

		Indicative		*Conjunctive*
Sing.	1.	ich ſang,	I sang	ich ſäng-e
	2.	du ſang-ſt		du ſäng-eſt
	3.	er ſang		er ſäng-e
Plur.	1.	wir ſang-en		wir ſäng-en
	2.	ihr ſang-(e)t		ihr ſäng-et
	3.	ſie ſang-en		ſie ſäng-en

1. In the CONJUNCTIVE the verbs modify the vowels (a, o, u, or au) of the imperfect indicative, and take the same suffixes as the present tense of the conjunctive [see example and XVIII]. Some verbs with the imperfect vowel a are (*a*) alternately used with the modified ä and ö, and others (*b*) take the modification ü instead of ä.

		IMPERFECT	
	Infinitive	*Indicative*	*Conjunctive*
To (*a*) belong:	beginn-en, to commence	ich begann	ich begänn-e or begönn-e
	beſinn-en, to reflect	„ beſann	„ beſänn-e or beſönn-e
	gelt-en, to be worth	„ galt	„ gält-e or gölt-e
	gewinn-en, to win	„ gewann	„ gewänn-e or gewönn-e
	ſpinn-en, to spin	„ ſpann	„ ſpänn-e or ſpönn-e
	ſchwimm-en, to swim	„ ſchwamm	„ ſchwämm-e or ſchwömm-e
	rinn-en to flow	„ rann	„ ränn-e or rönn-e
	befehl-en, to command	„ befahl	„ befähl-e or beföhl-e
	empfehl-en, to recommend	„ empfahl	„ empfähl-e or empföhl-e
	ſtehl-en, to steal	„ ſtahl	„ ſtähl-e or ſtöhl-e
	ſchelt-en, to scold	„ ſchalt	„ ſchält-e or ſchölt-e
(exception)	ſteh-en, to stand	„ ſtand	„ ſtänd-e or ſtünd-e
to (*b*) belong:	helf-en, to help	„ half	ich hülf-e
	ſterb-en, to die	„ ſtarb	„ ſtürb-e
	verderb-en, to spoil	„ verdarb	„ verdürb-e
	werb-en, to enlist	„ warb	„ würb-e
	werd-en, to become	„ ward	„ würd-e
	werf-en, to throw	„ warf	„ würf-e

The form with ä in group (*a*) is usually not employed where, in the pronunciation, the phonetic similarity of the imperfect conjunctive with other tenses of the same verb might lead to confusion, as in ich befähle, empfähle, ſtähle, ſchälte, which sound similar to ich befehle, empfehle, ſtehle, ſchelte. For the same reason the form with ä has been entirely abandoned in group (*b*).

2. Verbs which admit of *no modification* of the changed indicative vowel in the conjunctive form this tense by the suffixes shown in the conjugational example of XIX.

Examples: ſchreiben, imperfect indicative ich ſchrieb (ie not modifiable); imperfect conjunctive ich ſchrieb-e, etc.; beißen, to bite, imperfect indicative ich biß (i not modifiable); imperfect conjunctive ich biſſ-e, etc.

Where the modified conjunctive vowel coincides with another tense, it is best to use the *first conditional* [see Table V., page 747] in the place of the imperfect conjunctive—*e.g*, in the verb ſchwör-en, to vow [imperfect indicative ich ſchwor (or ſchwur)]; the imperfect conjunctive, with modification of the vowel, ich ſchwör-e (or ich ſchwür-e) coincides with the present indicative. 1. ich ſchwör-e; 2. du ſchwör-ſt, etc. The employment of the first conditional „ich würde ſchwören" [infinitive of the verb and imperfect conjunctive of the auxiliary verb „werden" [see Table V., page 747] prevents misunderstanding.

XX. The Adverbs are not, of course, subject to inflection by declension or conjugation.

Adverbs of place: hier, da, here; dort, da, there; oben, above; unten, below: vorn, in front, before; hinten, behind, after; innen, within; außen, out, without; fort, away, forth; weg, away, off; heraus', out; hin'ein, in, into; vor'wärts, forward, on; rück'wärts, backwards; etc.

Adverbs of time: wann? when? dann, then; jetzt, now; ſoeben, just now; heu'te, to-day; ge'ſtern, yesterday; einſt, once da'mals, then, at that time; immer, ſtets, always, ever; ſelten, rarely; nie, nie'mals, never; zuwei'len, sometimes; ſchon, already; noch, still, yet; hierauf, hereon, hereupon: nun, now, at present; etc.

Adverbs of manner, degree, quality, affirmation, negation, etc.: ſo, so, thus; ſehr, very; ziemlich, tolerably, pretty; wenig, little, few; meiſt, meiſtens, most, mostly; umſonſt', in vain; fer'ner, furthermore, besides; faſt, beina'he, almost, nearly; kaum, scarcely; ganz, quite; nur, only, but; allerdings', surely, certainly; keinesfalls, keineswegs, by no means; vielleicht', perhaps; ungefähr, about; ja, yes· nein, no; nicht, not; etc.

Adverbs of cause: darum, deshalb, therefore; folg'lich, consequently; alſo, thus; daher', thence; warum', wozu'? why? etc.

1. Nearly all adjectives can be used adverbially without undergoing any change of form. In the sentence: Der Gärtner iſt fleißig (the gardener is diligent) the adjective fleißig qualifies the substantive; whilst in der Gärtner arbeitet fleißig (the gardener *works* diligent*ly*), it modifies as *adverb* the action expressed by the *verb*.

Some adverbs and adverbial denotations are formed from substantives, adjectives, and verbs by the suffixes -s, -ſt, -lich, -lings, etc.; (abends, or des Abends, in the evening, of an evening; morgens, in the morning; jüngſt, lately; freilich, certainly, indeed; neulich, recently; begreiflich, conceivably; meuchlings, treacherously; blindlings, blindly; etc.), or by connection with prepositions, etc.

2 If a sentence opens with an adverb, the normal position of the finite verb is changed—the verb in this case must precede the subject. Examples: ich bin hier (I am here), but hier bin ich; er kommt nie (he never comes), but nie kommt er; der Gärtner arbeitet fleißig, but fleißig arbeitet der Gärtner. It will be seen that verb and subject are here in the same relative position as in the interrogative form [see IX.].

3. Some adverbs admit the use of the comparative and superlative, like the adjectives, but the formation of the adverbial superlative differs from the superlative in adjectives, as will be seen later.

EXAMINATION PAPER VI.

1. By which suffix is the past participle formed in the strong conjugation?
2. What is the characteristic feature of the present tense in the conjunctive?
3. What changes and modifications of the stem-vowel can occur in the present tense indicative of strong verbs, and in which persons?
4. How do strong verbs with the stem-vowel e form the imperative in the second person of the singular (familiar address)?
5. What are the inflections of the strong imperfect indicative in the singular, and in which instances does the second person take the inflection *with* or *without* the vowel?
6. Which verbs modify the vowel in the strong imperfect conjunctive, and what suffixes do they take in this tense?
7. Which are the modified vowels that can be employed alternately in the strong imperfect conjunctive of some verbs?
8. Under what conditions is it advisable to use the first conditional in place of the imperfect conjunctive?
9. Is there any difference between English and German adjectives, when used adverbially?
10. By which suffixes can adverbs and adverbial denotations be formed from other nouns?
11. What is the position of the finite verb in sentences and clauses introduced by adverbs, and in which category of sentences does the finite verb occupy a similar place?

Exercise 1:* Fill in the missing verbs with their correct personal terminaticns:

Der Hund ....; er .... ſeinen Herrn. Du ......
The dog bites; he bit his master. Thou cheatest

* Strong verbs used in this Exercise (the imperfect vowel in brackets): beißen (i), to bite: betrügen (o), to cheat; binden (a), to bind; geben (a), to give; fahren (u), to drive; ſchlafen (ie), to sleep; laufen (ie), to run; helfen (a), to help; rufen (ie), to call; fechten (o), to fight; graben (u), to dig; fliehen (o), to escape.

dich ſelbſt: Sie ...... mich. Du ...... Blumen;
thyself; you cheated me. Thou bindest flowers;
das Mädchen .... einen Kranz; der Vertrag .... ihn.
the girl bound a wreath; the agreement binds him.
Ich ..... ihm Geld, und er ...... fort;
I gave him money, and he drove away;
ich ..... nichts; du ...... mir das Geld,
I give nothing; thou givest me the money,
und er ...... dir den Vertrag. Wir .....
and he gives thee the agreement. We drove
fort und ......; ihr ..... ihn, aber er ......;
away and slept; you called him. but he slept;
du .... vorzüglich. Ich . .. und er ....
thou sleepest excellently. I drove and he ran
fort. Du ...... mich. Wir ...... die
away. Thou scoldest me. We bound the
Blumen und ihr ..... uns. Wir ..... euch Alles,
flowers and you helped us. We gave you all,
doch ihr ...... uns nichts; Sie ......, während
but you gave us nothing; you fought, whilst
ich ..... Er ..... mir und dann ...... fort;
I slept. He helped me and then drove away;
du .... gut; er ...... vorzüglich;
thou fightest well; he fights excellently;
ihr .... tapfer. Er ...... mit (3) ihm
you (*pl.*) fight bravely, He drives with him
und ..... den Gärtner; ſie ...... mit ihm;
and calls the gardener; she escaped with him;
Sie ..... den Gärtner und ...... ihm Geld;
you called the gardener and gave him money;
ſie ...... ihrem Manne; ſie ...... einander;
she helps her husband; they help one another;
Sie ...., du ...., er ...., wir ....,
you (*pl.*) sleep, thou drivest, he runs, we dig,
ihr ..... uns und ſie ..,..; ich ....; ihr ....
you help us and they fight; I dug; you helped
mir and er .... mir Geld!
me and he escaped. Give (*sing.*) me money!
.... mir! .... mit mir! ..... mich!
Help (*sing.*) me! Fly (*sing.*) with me! Call (*pl.*) me!
.... tapfer! .... gut! ......
Fight (*sing.*) bravely! Fight (*pl*) well! Give (*pl.*)
mir Geld! ...... Sie mir Geld! ......
me money! Give me (*civ. addr.*) money! Fly (*pl.*)
mit uns! ...... Sie mit mir!
with us! Fly (*civ. addr.*) with me!

EXERCISE 2. Put the adverbs of the following sentences at the beginning of each sentence:

Du bleibſt heute bei mir; es iſt vorn; er
You stay to-day with me; it is in front; he
fuhr vorwärts; er kam heraus; ſie war unten;
drove on; he came out: she was below;
wir ſahen ihn dort; es geſchah ſoeben;
we saw him there; it happened just now;
wir kamen geſtern; ihr reiſet heute; alles
we came yesterday; you travel to-day; all
war umſonſt; er kommt ſelten; ich ſagte es immer;
was in vain; he comes rarely; I said it always;
(I always said so)
es iſt ſo; er bemerkte ferner ....; wir reiſen
it is so; he remarked further ....; we travel
keineswegs; er brach beinahe ſein Bein;
by no means; he almost broke his leg;
ich fragte mich: warum?
I asked myself: why?

Continued

WORKING OF BIOLOGICAL LAWS

Mendel's Experiments with Peas and his Important Discovery His Law of Heredity. The Transmission of Definite Characters by Heredity

Continued from page 1316

By Dr. GERALD LEIGHTON

A Scientific Romance. We now come to a phase of the heredity question which is at the present moment exciting a vast amount of attention, and is the object of a number of experiments which are being carried out in this country. It is the discovery and the application of a law of heredity at once so simple and so far-reaching that the truth or otherwise of it becomes a matter of vital importance. The discovery of the law and its subsequent history is a veritable scientific romance.

The credit of this remarkable discovery belongs to a monk, Gregor Johann Mendel, who was born in 1832, in Austrian Silesia. In 1843 Mendel entered the cloister of an Augustinian foundation in Altbrünn, and became priest in 1847. From 1851 till 1853 he studied natural science in Vienna, and, returning to the cloister, became a teacher in Brünn. In 1854 he began his remarkable series of experiments in the gardens of the cloister, and he continued these for about ten years. He communicated his results to the Brünn Society of Naturalists, in 1865, and these were published in the journal of that society in 1866. Later he became abbot of Brünn, and finally he died in 1884, practically unknown as a scientific worker. At the present time his work may be said to be dominating the thought of students of the phenomenon of heredity, and, such is the pathos of life, his name will be immortal in the annals of science. His brilliant discoveries remained almost unknown, not merely during his own life, but for sixteen years after his death, as it was not until so recently as the year 1900 that his work was rediscovered, confirmed, and given to the modern scientific world by Professor Hugo de Vries, to whom we have already referred. Curiously enough, at this lapse of thirty-five years from the time Mendel first communicated his results, the rediscovery and confirmation of it came almost simultaneously from De Vries in Holland, Cörrens in Germany, and Tschermak in Austria ; all in 1900. With the exception of Mendel, the history of the study of heredity in the nineteenth century is little more than a mass of confused and apparently contradictory results, which Darwin, in 1868, in his "Animals and Plants," attempted to reduce to some order.

Why Other Investigators Failed. Looking back now it is easy to see why Darwin and others failed to discover a law of heredity. It was because of the lack of simplicity in methods. They attempted to deal with complicated cases, and failed to trace events through a sufficient number of generations. Mendel concentrated his experiments on one species, and dealt with simple characters *singly* ; further, he worked with large numbers of individuals, and continued his experiments through several generations. In this way he was able to discover a law of heredity which will ever be associated with his name and which bids fair to revolutionise the modern conceptions on this subject, and therefore of biology. For the following account of Mendel's work and law we are indebted to Mr. C. C. Hurst, of Leicestershire, who is at present carrying out further experiments on plants and animals, with a view of ascertaining how far Mendel's law is applicable, and in what directions.

Mendel's Experiments on Garden Peas. After experimenting with several kinds of plants, Mendel finally selected the garden pea as a suitable subject. Its advantages are many and obvious. Most of the races are constant, they breed true from seed, and many of the characters are quite distinct. Moreover, if two sorts are crossed, the hybrids which result are fertile, and can be bred from continuously. Again, the flowers of the pea are *naturally self-fertilised before the bud opens*, so that fertilisation by insects does not disturb the results. More than that, it is easy to apply pollen artificially and in sufficient quantity without other pollen affecting the result, because the pistil is ripe before the stamens. Then, as the pea is an annual, a generation can be grown every year, and large numbers obtained in a small area of ground. Finally, two characters at least—the colour of the seed and the shape of the seed—can be determined a few weeks after the cross is made, so that two generations of these can be observed in a little more than a year after the first cross; and so on through many generations. All these advantages make the pea an ideal plant for experimental purposes of heredity.

Mendel dealt with single characteristics, and watched the effect of crossing different ones. That was the secret of his success. The characters, or traits, offered by the pea were numerous. Thus, he dealt with colour of seed, shape of seed, colour of flower, colour of pods, smooth or constricted ripe pods, tall and dwarf stems, and so forth. The fact that some pea seeds are yellow and others green, some flowers purple, others white, some seeds round, others wrinkled, some stems tall and others dwarfed, enabled him to watch each character separately when the plant bearing it was crossed with another of different type.

If we examine an ordinary ripe pea seed, it will be found to consist of at least two distinct parts, the seed-coat, or skin, which easily peels off, and the "cotyledons" within. The two cotyledons are, of course, part of the embryo plant, and therefore, if the seed has been crossed, the cotyledons partake of the nature of both parents. On the other hand, the seed-coat is a purely maternal character like the pod itself. Ignoring the colour of the seed-coat, therefore, the colour of the cotyledon within may be alone considered at present. It is further found that most pure races of peas may be divided in this way into two classes, *yellow* and *green*.

Yellow and Green Peas. Mendel crossed a pure yellow pea with pollen from a green pea. The resulting offspring were *all yellow peas*. He then changed the sexes, and crossed a green pea with the pollen of a yellow pea. The result was the same, *all yellow peas*. Sex made no difference. Many repetitions of these experiments gave no other result. He therefore concluded that pure yellow peas were "dominant" over pure green peas as far as this character was concerned, irrespective of sex. Now note what followed. Mendel then sowed the *hybrid yellow* peas of this first generation and allowed the plants raised from them to fertilise themselves individually. The result was that *each of the plants in the second generation bore seeds of the two colours, yellow and green, both colours being found in the same pod*. What did that involve? It proved that the character of greenness was *contained in* the hybrid yellow peas, although they showed no indication of it. There was no other possible source. The greenness had been latent in the first generation, and came out in the second. Since the cross between the pure yellow and green peas gave hybrid yellow peas, Mendel termed the yellow character "dominant" over the green, and the latent green character he termed "recessive"—it had receded in the first generation only to reappear in the second. This was the first important step.

The Second Generation. Mendel next proceeded to test the yellow and green peas of the second generation, and herein showed his keen appreciation of the problem of heredity. He had now two sorts of peas to deal with, green and yellow, to all appearance like those he started with. He first sowed the green peas, and allowed the plants to fertilise themselves individually. The result was that the peas of the third generation *all produced green seeds*. This he repeated for six generations, and in each case nothing but green peas were produced, there being no trace of the dominant yellow hybrid ancestor. The recessive green character, after reappearing, *bred true for ever*.

The Important Discovery. At this point Mendel made his most important discovery. Earlier experimenters had found that the offspring of hybrids resembled their grandparents, as did these green peas. Mendel alone, however, carried the experiment further, to see if they bred true. As stated, he found that the green peas did so. They were, therefore, pure green peas with no taint of yellow, in spite of the fact that both parents were dominant yellow and two grandparents likewise.

But what about the yellow peas of the second generation, the offspring of the hybrid yellows? He allowed these to self-fertilise as before, and got an astonishing result. The offspring proved to be of *two distinct kinds*. Some were pure yellow (just as the greens had been pure green), but others were *hybrid yellow*, and this was proved by the way they bred. Some produced nothing but yellows generation after generation. They were, therefore, pure yellow. But others, also yellow, produced plants each bearing a mixture of yellow and green peas, often in the same pod, just as their own parents did. The pure yellow remained fixed, and bred true to type for the six generations in which they were tested, while the hybrid yellow peas split up into pure yellow, hybrid yellow, and pure green peas, as their parents did. Throughout all these experiments the pure yellow peas were absolutely indistinguishable from the hybrid yellow in appearance; their real nature was only to be determined by the nature of their offspring, the way they behaved when bred from. The pure yellow peas which came from the hybrid yellows, and the pure green peas which also came from the hybrid yellow, have been termed "extracted" yellow and green respectively.

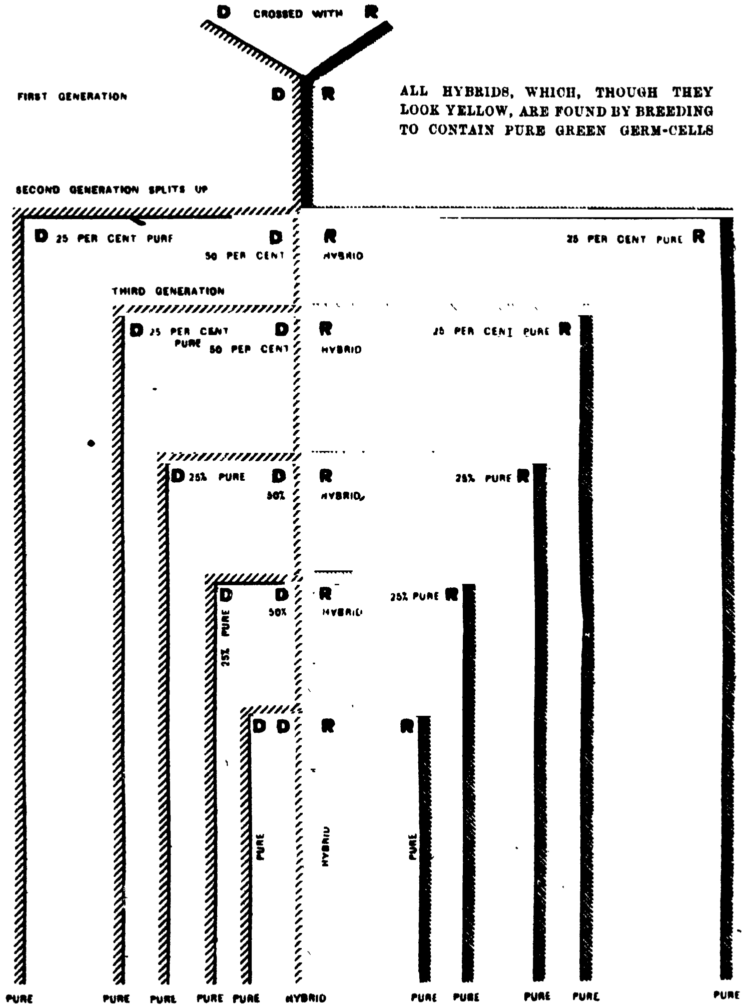
The Total Result. Summarised, the results were as follows: Pure yellow crossed with pure green peas produced offspring which were all hybrid yellow. These hybrid yellow when self-fertilised, produced offspring of distinct types—*viz.*, pure yellow, hybrid yellow, and pure green. In other words, one of the two distinct types (the hybrid yellow) of the second generation was really composed of two, but this was only discovered by breeding them again.

This purity of the extracted yellow dominants and of the extracted green recessives was entirely unsuspected, and it lies at the very basis of the Mendelian principles of heredity.

But this was not all. When Mendel came to count up all the individual peas produced in the successive generations, he found that the characters appeared in a certain definite proportion of offspring. In the second generation, out of 8,023 seeds there were 6,022 yellow and 2,001 green, practically a ratio of 3 to 1; and out of 519 plants raised from these yellow seeds 166 were all yellow seeds, while 353 bore both yellow and green seeds mixed, practically a ratio of one pure yellow to two hybrid yellow. So that the yellow and green seeds of the second generation really consisted of, on the average, one pure yellow, two hybrid yellow, one pure green; or, expressed in percentages, 25 per cent. pure yellow, 50 per cent. hybrid yellow, 25 per cent. pure green. The great and important idea of Mendelism, however, lies not in these proportionate figures, but in the idea of "gametic purity," the truth that a pure character may be carried on by germ-cells through a generation which does not exhibit the character to the next in which it reappears.

In Mendel's day it was known that each individual plant and animal developed from a single germ-cell, and that this cell was, as a rule, fertilised, and was then the result of the union of an egg (from the female) and a sperm, or pollen (from the male). Experience showed that a pure yellow pea self-fertilised produced pure yellow peas; similarly a green pea produced green peas; and from this Mendel concluded that the pure yellow peas gave off egg-cells and pollen-cells which contained the necessary factor for producing the yellow character, and similarly that green peas gave off germ-cells which contained the factor for the green character.

The following graphic representation of Mendel's Law will, perhaps, make it clearer. Two characters only are dealt with, one of which is Dominant (D) over the other, which is Recessive (R). These correspond to any two characters such as the Yellow and Green in the text.



ALL HYBRIDS, WHICH, THOUGH THEY LOOK YELLOW, ARE FOUND BY BREEDING TO CONTAIN PURE GREEN GERM-CELLS

DIAGRAM ILLUSTRATING MENDEL'S LAW

Mendel's Hypothesis. According to this hypothesis, when a pure yellow pea is self-fertilised, or pollinated, with another pure yellow pea, the yellow factor—which may be expressed by Y—in the egg-cell unites with the yellow factor (Y) in the pollen cell, the male element with the female element, and gives rise to a pure yellow pea of the constitution YY. In the same way a pure green pea itself fertilised, or pollinated, from a pure green, gives rise to a green pea GG. When, therefore, a pure yellow pea is crossed or pollinated, with a green pea, or vice versâ the yellow factor unites with the green factor G, and gives rise to a hybrid yellow-green pea GY, which looks yellow because yellow is dominant. It is really a yellow-green in nature and its breeding proves this. The important idea in the Mendelian hypothesis is that *the factors Y and G which come together in fertilisation in the hybrid YG still retain their identity and individuality; they do not really blend. Therefore, when the hybrid gives off its germ-cells (either male or female), the factors Y and G separate again, so that each germ-cell contains either the Y or the G factor, but not both.* On this hypothesis, the hybrid YG gives off, on an average, egg-cells, 50 per cent. of which contain the yellow factor, and 50 per cent. the green factor. Similarly, the hybrid YG gives off pollen-cells, 50 per cent. of which contain the yellow factor, and 50 per cent. the green. So that YG, self-fertilised, as in Mendel's experiments, would on the average give the following different unions of germ-cells (each line representing one of the four possible modes of combining two distinct characters, together with the result of such a combination):

1 Y (male) + 1 Y (female) = 1 YY offspring
1 Y (male) + 1 G (female) = 1 YG offspring } 2 YG
1 G (male) + 1 Y (female) = 1 YG offspring }
1 G (male) + 1 G (female) = 1 GG offspring

The total offspring of YG, self-fertilised would therefore on the average be found to consist of :

1YY : 2YG : 1GG

that is, 25 per cent. pure yellow, 50 per cent. hybrid yellow, and 25 per cent. pure green.

Germ-cell Purity. The simple idea of germ-cell purity in respect of special characters—"gametic purity," as it is termed—is the most important of Mendel's discoveries, and upon this all the complicated calculations of the probabilities of inheritance in the mating of individuals are founded. We have restricted ourselves here to the illustration of what occurs when a single character is taken—namely, seed-colour; but the law applies to combinations of characters, and becomes a matter of working out by mathematics. The interest in the present and future is to determine which of all the characters of plants and animals are Mendelian—that is, conform to this law. The list is being added to daily, and amongst those characters which have been shown to follow this law may be mentioned the coat colour of rabbits and horses, as well as the eye colour in human beings, all of which have been investigated by Mr. Hurst. Amongst others, Mr. Bateson and Miss Saunders, at Cambridge, have made many experiments with garden stocks, and with certain characters in fowls, as well as with sweet-peas. All these have confirmed the truth of the Mendelian hypothesis, and the cases in which it is demonstrable are becoming very numerous.

We have dealt here with the simplest outline only of the matter, which is all that is necessary for our purpose. A careful examination of the explanatory diagram will help to a clear conception of Mendel's experiments, and give some idea of the importance of the results which have been established. When once we know that certain characters are bred pure and are transmitted through individuals which may show no sign of them, it is possible by Mendel's law to foretell exactly what the offspring of individuals having those characters will be. It is thus a true law of heredity, and not merely a statement of ancestral traits.

Application of Mendel's Law. We have now briefly reviewed the most important theories in the science of biology, and it becomes our task to endeavour to gather together all the various strings of thought and weave them into one strong band of conviction. We appreciate the fact of universal variation in offspring, we see the working of natural selection in the world of life, we understand how the phenomena of heredity are possible, and we recognise the fundamental importance of these phenomena. We must now turn our attention to the practical application of these facts in individual lives and in society in order to gain some idea of man's present as well as past evolution.

How Heredity Tells in the World. A very important question in this connection is the effect of the use or disuse of various parts of the body upon the individual and the offspring. It is held by Lamarckians that many of the higher animals must owe some of their characters to the inheritance of these effects. We refer now to those characters which are developed in response to what we term "exercise." They are adaptive acquirements. They are more prominent in animals than plants, because the latter do not use their parts in the same sense that animals do; they attain their full development without any special stimulation other than nourishment, light, moisture, and warmth. The same is true of plant-like animals, such as sponges, and of such animals as insects, as well as of fish and amphibians to a great extent. But when we come to the highest vertebrates—birds and mammals—and especially the highest mammals, we find that many structures attain their full development only in response to the stimulus of use or exercise, and that in the absence of this the part fails to develop, or, if already developed, undergoes wasting, or atrophy. Thus, if the limb of a child be rendered immovable by paralysis or by a joint disease so that it cannot be used, it does not develop into a fully-formed adult limb, or it undergoes wasting in the case of an adult.

Acquired Development. On the other hand, if a healthy individual gives a part of his body more than ordinary use or exercise, the structures concerned develop proportionately up to a certain point, and the development is termed "acquired." Thus, the blacksmith's arm develops in response to the stimulus of constant use. This development out of the ordinary is abnormal for the average man. But the important point is that in human beings even the normal healthy development is attained only by use of the various parts of the body. The full development of the normal arm as well as of many other structures, is *acquired*. Some structures such as the nose, eyes, teeth, ears, nails, and sexual organs, do not owe their development to use and exercise. It is *inborn*. In fact, the adult human being differs from his infant condition chiefly in the characters which are acquired by use and exercise. In the features of his face he differs in inborn characters, but in the structures of the body, limbs, and brain, the differences are those which come from use of those parts. An adult man, therefore, is largely a huge superstructure of use-acquirements built upon a comparatively small foundation of inborn germinal traits.

Can the evolution of the highest animals be attributed to the inheritance and accumulation during generations of the effects of use and disease ? Are such modifications transmitted ? This question must be answered.

Continued

continued from page 1228

METHODS OF COOKING

Boiling, Steaming, Stewing, Braising, Roasting, Baking, Broiling, Frying. Stock-making. General Rules to be Applied

THE methods of cookery may be divided into three classes. Cooking by:

1. Moist Heat.
   Applied by (*a*) immersion in hot liquids —*i.e.*, boiled meat.
   (*b*) The vapour rising from boiling water —*i.e.*, steamed puddings.
2. Dry Heat.
   Applied by exposure to (*a*) radiant heat, as in cooking roast and grilled meat.
   (*b*) Conducted heat or hot air, as in cooking baked foods.
3. Immersion in Hot Fats.
   (*a*) Deep frying, as in cooking croquettes.
   (*b*) Shallow frying, as in cooking pancakes.

Principal Method of Boiling. The term boiling indicates the cooking of various foods by immersing them for certain lengths of time in boiling liquid—*i.e.*, liquids in bubbling motion. This cookery process is one of the simplest and, within certain limits, the most economical, as well as the most commonly used.

It is, however, often directed to be used when the actual boiling point would render the foods almost worthless—*i.e.*, boiled custard, boiled meat. With certain exceptions, much of the so-called boiling is performed at a temperature a little below that of 212° F., which is the boiling point of water and stock. Liquids boil at different degrees; milk, for instance, at a lower temperature than water, while fats and oils have to be raised to a far higher degree before they can be used for cooking foods.

Foods are boiled for two different objects:

As a preliminary step, for a few minutes, so that by rapidly hardening the outside albumen the pores of meat, fish, etc., are sealed, and the juices which give flavour and nutriment are thereby *retained.*

Also as a means of *extracting* nutriment and flavour into the liquid, as when broths, stocks, etc., are required. In this case the meat and bones are placed in cold water, brought slowly to boiling point, and then boiled steadily for the prescribed time.

Actual boiling heat should be used for:

1. All green vegetables and many other varieties.
2. Suet and similar puddings.
3. Sealing the pores of meat, fish, etc., during the first few minutes.
4. Rendering stocks.
5. Making syrups.
6. Evaporating liquids—*i.e.*, from a too thin sauce or soup, vinegar from sauces, etc.
7. Rice, for curries or macaroni, etc.

Simmering. It should be borne in mind that water, etc., allowed to "gallop," as it is called—or, in other words, to boil furiously—is, with a few exceptions, not any more effective than if it were steadily simmering. The liquid used is merely passing off in the form of steam which, as it condenses, renders the walls of the kitchen damp and unhealthy.

Simmering foods consists in cooking them in liquids that are gently bubbling on one side of the pan, but not all over the surface as in boiling. Simmering point is 180° F., or in some cases as low as 170°, and it is this effective, digestible cookery process that is required after the preliminary boiling for "boiled" meats, poultry, fish, etc.

Rules for Boiling Puddings

1. Grease all moulds or basins.
2. See that they are full.
3. Tie over them a scalded and floured cloth.
4. Put them into boiling water, and see that it covers them.
5. Boil them steadily, adding more boiling water as it evaporates.

Rules for Boiling Green Vegetables

1. Trim, soak, and wash them well.
2. Put them into boiling water with one tablespoonful of salt to every two quarts of water, and a piece of soda, about the size of a pea, to soften the water.
3. Boil them quickly without the lid.
4. Skim them well.
5. Strain them off directly they are tender draining off as much moisture as possible.

Rules for Boiling Potatoes

1. Select those of a uniform size as far as possible.
2. Peel old ones thinly and scrape new ones.
3. Lay them in cold water after peeling.
4. Put old potatoes in cold salted water, and new in boiling salted water with a sprig of mint.
5. Boil them gently till tender but not mashed.
6. Drain off all water.
7. Stand the potatoes in the pan with the lid partly off to dry by a low fire.

Rules for Boiling Meat

1. Wash salt meat and wipe fresh meat.
2. Put salt meat into tepid water and fresh into boiling water.
3. Boil both for five to ten minutes, then at once lower the heat and simmer them for the rest of the time.
4. Allow fifteen minutes to each pound the joint weighs, and fifteen minutes extra if the meat is fresh.
5. For salt meat, fresh pork, or solid cuts without bone, allow twenty to twenty-five minutes with an extra twenty minutes on the whole joint.
6. Save the liquor in which the meat was cooked for soups, etc.
7. Always add pot vegetables to the water in which the meat is to be boiled.

RULES FOR BOILING FISH

1. Well wash and trim the fish.
2. Place it in hot, but not boiling, water, with a little salt and vinegar—the latter helps to keep it white. Cold water would extract the juices; boiling would crack the thin skin and render it unsightly.
3. Simmer the fish gently, and skim it well.
4. The time allowed depends more on the thickness of the fish than its weight, usually about eight to ten minutes to each pound is sufficient.
5. Remove the fish at once from the water when cooked, and drain it well.

Method of Steaming. This process consists of cooking foods in the vapour arising from boiling water. It is a much more lengthy but far lighter and, therefore, more digestible method of cooking than boiling, as the gradual process renders fibres, etc., softer. In many instances it is more economical and nutritious —*i.e.*, boiled vegetables and fish lose much of their valuable mineral matter in the water, which is then usually thrown away; whereas, if steamed, none of the nutritious elements would be lost. Other advantages are that it is impossible for water to come in contact with the food, provided a piece of greased paper is laid over it to prevent the steam condensing on the lid and falling back on to it. Also, over one pan of boiling water three or more different foods may be cooked by using different steaming compartments fitted one above the other. A homely substitute for a steamer is to stand the basin in a saucepan with boiling water to come only half way up the basin, taking care that the water does not boil away.

Method of Stewing. This method may be described as resembling a very slow process of simmering, but only a small amount of liquid is used, and this is usually served with the solid matter and forms the gravy or syrup, according to the nature of the dish.

This latter point is important, because the more soluble and nutritious elements which are extracted are not wasted, as is so often the case with boiling and simmering, but are served with the meat.

For cooking meat, stewing is the most economical method, for the following reasons:

Coarser and cheaper parts of meat can be used, as slow cooking in moist heat softens the coarse fibres and renders the sinewy portions gelatinous.

Only a little fuel is needed, as slow cooking is essential.

Little attention is required during the cooking, since there is no risk of the food burning.

There is no waste of nutritious elements, for the solid and liquid parts are both served.

Less meat is required, as a considerable proportion of vegetables is added, giving flavour and making the food more wholesome, and adding bulk.

The meat to be stewed may be either:

1. Partially fried before stewing, as for haricot mutton, stewed steak, etc. This is only suitable if the more juicy and tender cuts of meat are to be used.
2. Putting the meat into cold liquid and bringing it to boiling point, as for Irish stew. This method should be adopted if the meat is tough and gristly. The process of stewing can be equally well performed in a slow oven or on the top of the stove. The utensil used, whether it be a "casserole," pie-dish, or earthenware jar, must be kept tightly covered.

RULES FOR STEWING

1. If the meat is juicy, seal the outside albumen rapidly by frying it first, or half roasting.
2. If tough, put it in a cold liquid and bring it to boiling point.
3. If likely to be very tough, lay the meat for a few minutes in vinegar; this softens the fibres.
4. The tougher the meat, the longer and slower must be the cooking.
5. Stews allowed to boil will have the meat tough and tasteless, and the gravy wasted by evaporation.
6. Keep the utensil closely covered, so that the aroma and flavours are retained.

Method of Braising. This term is derived from the French "braise," or live coal, and indicates the use of a shallow pan with a tightly fitting lid and a sunken top, in which the live coal (charcoal) is placed. The food, therefore, is cooked between two fires, and is a cross between baking and stewing. Where a regular braising-pan is not procurable, an ordinary shallow stewpan, with a well-fitting lid, answers the purpose excellently, and often the top heat is omitted. It is a process that greatly develops the aroma and flavour of the food cooked, and is much used by the French.

RULES FOR BRAISING MEAT, ETC.

1. Prepare and cut in large pieces about 6 oz. of mixed vegetables—carrot, turnip, onion, and celery—also a bunch of herbs and parsley; this amount is sufficient for about 3 to 5 lb. of meat.
2. Fry these in the braising-pan in good beef dripping till brown.
3. Make a bed of them in the pan to lay the meat on.
4. Add about one pint of stock, and lay on the meat.
5. If the meat is very delicate, such as sweetbread, chicken, etc., cover it with a greased paper to prevent scorching by any hot coals on the top.
6. Cover the meat tightly, and simmer it very gently for the required time.
7. Lard the meat if it is very lean.
8. When the meat is cooked, strain off the stock, reduce it by sharp boiling without the lid, and after careful seasoning use it as the gravy.

Method of Roasting. Roasting is one of the most popular culinary operations. By the sharp heat and free current of air, the flavour is more developed than by any other process, and the juice is better retained in the joint.

By roasting is actually meant cooking the meat by rays from an open fire, though nowadays oven roasting is much practised. Still, many experts on the matter insist that a joint baked, even in an oven with the most up-to-date ventilation, can never compare with a roasted one.

The fire needs special care for this method. It must be clear, bright, and well banked up before the joint is hung in front, so as to avoid, as much as possible, putting on much coal during the cooking. "A little and often" is the best rule to remember for those in charge of the fire, and it is far the best to push all the live coal to the front, putting on the fresh at the *back*, so as to prevent any smoke flavouring the meat. The "bottle," or "roasting jack," is generally used to revolve the joint before the fire, and a tin meat-screen containing the dripping-tin, with a basting ladle, is a most convenient arrangement. It is essential that the meat be screened, or much of the heat is wasted in the kitchen. A screen keeps off any draught, and the polished metal reflects the heat again, and aids the cooking.

Unless frequent basting is done at least every ten minutes, the meat will become dry, shrivelled, and the flavour but poorly developed. This is another reason why oven roasting is less successful, as cooks find it too much trouble constantly to open the oven door, lift out a heavy hot tin, baste the meat, and put it back again.

RULES FOR ROASTING

1. Expose the joint to great heat for the first ten minutes, to harden the outside albumen, and keep in the juices.
2. Then lessen the heat, or the meat will be dry and burnt on the outside and raw within.
3. Keep up the fire well, because meat roasted slowly dries from the gradual evaporation of its juices.
4. Baste the meat at least every ten minutes.
5. Should the meat be very lean, add some dripping to use for basting.
6. Note that the thickest part of the joint is so hung that it is in front of the hottest part of the fire, which is a little below the centre.
7. Delicate meats, such as fowl, game, etc., should be wrapped in well-greased paper till about the last twenty minutes, when it is removed to brown the outside. This is often done, also, to protect the fat of a sirloin or loin of mutton at first.
8. Gravy for roast meat should be clear and not thick, except for white meats, such as veal, pork, and fowls.

The proper time to allow for roasting meat is a difficult point, and experience is the only guide, as the age, quality, and condition of the meat—that is, if freshly killed or hung—must be considered, as well as individual tastes. The rough calculation usually followed is fifteen minutes for every pound the joint weighs, and an extra fifteen or twenty minutes on the whole joint. For pork and veal, however, allow twenty minutes for every pound, and half an hour over that time. Solid, boneless, or stuffed joints will need this last calculation, even if beef or mutton; so, also, will freshly killed meats and the flesh of young animals.

It does not do, however, always to increase the time in exact proportion to weight if the joint is very large. A safe guide is that if the flesh in the thickest part *gives* when pressed with the fingers, it is sufficiently cooked for most tastes; if it seems to *resist* the pressure, cook it for a longer period. Or note if the steam from the meat draws to the fire, and the joint appears to be smoking, it is then pretty sure to be nearly, if not quite, done.

TIME-TABLE FOR ROASTING

Turkey, 8½ lb. ..	about	2½ to 3 hours
Small turkey or goose, 6 lb.	,,	1½ to 2 hours
Large fowl	,,	1 hour
Hare	,,	1¼ hours
Rabbit	,,	¾ hour
Pheasant, large .. .	,,	¾ hour
Pigeon	,,	½ hour
Partridge..	,,	20 to 25 min.
Woodcock	,,	½ hour
Grouse	,,	½ hour
Sirloin of beef, 10 lb.	,,	2½ to 3 hours
Leg of mutton, 6 lb.	,,	1¾ hours
Leg of small lamb ..	,,	1¾ hours
Veal, 5 lb.	,,	1¾ hours
Joint of pork, 4 lb. ..	,,	1¾ to 2 hours

Method of Baking. This is one of the most convenient and oldest methods of cooking on record. To be successful, it is most important to see that the oven in which the food is to be shut up is *perfectly clean*, otherwise the fumes of stale and burnt grease, burnt syrup boiled out of tarts, etc., will speedily ruin the flavour of dishes cooked in it, especially should they be of a delicate nature like milk puddings. This is an important point much neglected. In many ordinary coal-ranges, the top shelf is the hottest part, unless it is fitted with a reversible damper, by means of which the flame is directed so as to pass first under the oven, then out into the flue over the top. This is described as bottom heat. In most up-to-date stoves there is one oven with "bottom heat" for bread, cakes, pastry, etc., and another one with "top heat" arranged for roasting.

Grilling and Broiling. The latter is the ancient term for grilling, and is derived from the French "bruiller" (to burn). Though both words are still in use, they mean practically the same thing. The process is an exceedingly simple one, and has been in practice in various primitive forms from very early times. Grilling consists in quickly cooking foods before or over a very sharp, clear fire. The rapid hardening of the outside albumen prevents evaporation, and the whole operation and result is much the same as roasting, only on a miniature scale. Like roasting, it is expensive, as only small, juicy pieces such as rump steak, chops, cutlets, etc., are suitable to use, and a clear, quick fire is imperative. It is, however, a most savoury and digestible method, with the extra virtue of being speedily performed.

A charcoal fire is considered the best, owing to its steady, intense heat without smoke.

Care is needed not to make holes in the meat with hooks or forks through which the juices would escape, and to prevent, as much as possible, grease dripping off into the fire, as the flare it causes imparts an unpleasant, smoky taste to the food. A smoky fire may be cleared by throwing on to it a little salt.

The time for cooking will depend more on the thickness than on the weight of the food to be grilled. A chop or steak of average thickness will take from about ten to twelve minutes, and should be frequently turned. The gridiron is most handy for cooking; besides meat, tomatoes, fish, mushrooms, ham, spatchcock of game, or poultry, can be treated in this way.

Method of Frying. This may be described as boiling foods in correctly heated fats or oils, but, owing to the intense heat of the fat or oil used—the temperature being far higher than boiling water—the foods cooked do not become soft and, if overcooked, mashed; but they acquire a crisp, dry surface, brown in colour, and if fried too long, become a black, charred mass. Frying is the quickest method of cooking, and, therefore, most convenient. It is also savoury and wholesome if carried out rightly; but when applied to all meats indiscriminately, as is so frequently done amongst the poorer classes, the injudicious use of the frying-pan is to be greatly deplored.

The two kinds of frying are: Deep, or wet frying, and shallow, or dry frying.

Deep, or *wet frying* is done in a deep pan that contains sufficient fat to at least cover the food to be fried. Examples: Fish, fritters, rissoles, etc.

Shallow frying is done with just enough fat to prevent the food sticking to the pan. Examples: Pancakes, cutlets, liver and bacon.

For the first kind, the foods, in many cases, should be coated with either egg and crumbs, batter, or even flour, to protect them from the great heat of the fat. In the second kind, the longer one of the two, it is necessary to turn the food so as to brown both sides.

A mixture of clarified beef or mutton fat makes an excellent frying medium, although oil is greatly advocated by many.

Temperature of Frying Fat. The degree of heat is the all-important point; it is so simple, and yet fried foods are often a failure through carelessness.

No food must be put in the pan until a faint bluish smoke rises from the centre of the pan of fat—not merely when it rises from the greasy edge. The density of the smoke will show whether or no a great degree of heat has been reached, for all foods do not need the same degree.

Foods put in fat before a smoke rises from it become sodden with grease, soft, and badly coloured. Some people prefer to throw into the fat a small piece of bread, and see how rapidly it turns a golden brown.

Remember that if the smoke rises in unpleasantly heavy clouds the fat is burnt, is unfit for use again, and foods cooked in it will often give rise to severe indigestion. Overheated fat will eventually burst into flame.

Rules for Frying

1. Have the pan and foods as dry as possible, as moisture causes hot fat to splutter.
2. Never put foods into the fat until a bluish smoke rises from it.
3. Put only a few pieces of food in at a time, or the temperature is too much lowered.
4. Drain all foods, except cutlets, kidneys, sausages, and bacon, on paper to remove grease, but never do this if it would entail loss of gravy that might flow from them.
5. Be careful that the fat does not burn.
6. Cool the fat when done with; strain it, and save it for future use.

It is a mistake to think that because water bubbles when it boils, if fat bubbles it must also be ready for frying purposes. This is not so. Fat that bubbles merely shows to the cook that moisture in some form is mixed with the fat. This moisture must be boiled out of the fat—evaporated, that is—and as it passes off in steam, the fat will gradually bubble less, till at last it is *still*. Wait a few seconds longer, and then will come the desired smoke, and at last the foods can be put in the pan. Household dripping generally contains moisture, often gravy. Remove any scum that may rise to the top of the fat as it heats.

Making Stock. Stock is the water in which bones, meat, fish, or vegetables have been cooked, when the substance itself is not to be eaten, the object being to extract the nutriment and flavour from the ingredients for the liquid in the stock-pot, which is to make a foundation for the soups, sauces, etc.

Pot liquor is the water in which meat, vegetables, and fish have been cooked, when the substance was to be eaten. It is, therefore, much weaker than stock, as the object has been to retain all flavour and nutriment possible in the ingredients. There are various kinds of stock.

1. Fresh meat stock, brown or white in colour.
2. General stock, such as is made by boiling the suitable household scraps in the stock-pot.
3. Fish stock for soups, sauces, etc.
4. Vegetable stock, often thrown away, though it might well be used in place of water, which, as it should be borne in mind, is the resource of a thriftless cook.

Stock is required as the foundation of all meat soups, thick and thin, brown and white. Also for most savoury gravies and sauces.

Special stock is often required for high-class soups, such as consommé, when nothing except fresh meat, bones, and vegetables must be used; but the same rules will hold good for it as for the more ordinary household varieties.

The Stock-pot. The stock-pot is usually a well-tinned iron, copper, or steel vessel, fitted with a tap and strainer; but a saucepan in good condition will answer the purpose well. It should be started with a pint or so of cold water, and into it be put all bones and scraps of raw or cooked meat, poultry or game, providing the latter is not "high"; also surplus pieces of vegetables, drops of gravy, etc. The contents should simmer all day, and be strained off each night into a clean basin.

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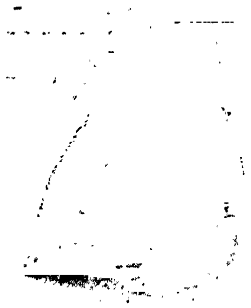

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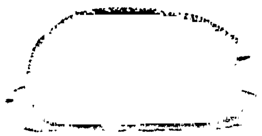

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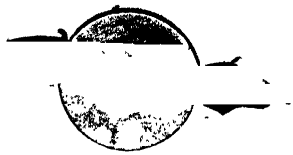

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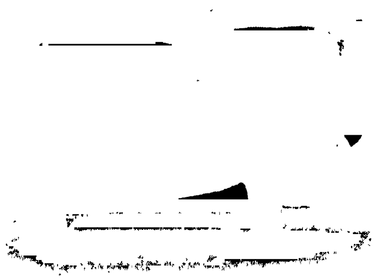

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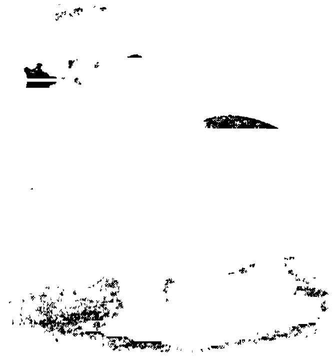
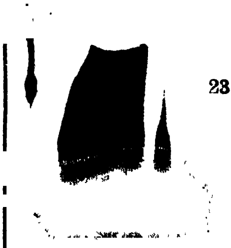


234. HIPPOPOTAMUS



235. GIRAFFE

236. ELEPHANT

238. BEAR

237. LION

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ZOOLOGY: CLASSIFICATION OF ANIMALS

Principles underlying the Study of Animal Life. Groups of Animals. Vertebrata, or Backboned Animals. Mammals and Orders included in the Class

Continued from page 1373

By Professor J. R. AINSWORTH DAVIS

WE have already had occasion to notice several of the relations between animals and plants, some of primary importance to both, others less far-reaching in their nature. The interconnection between flowers and insects is an attractive instance of the latter, while broader issues are involved when breathing and feeding are taken into consideration.

Breathing. Every living organism, whether plant or animal, breathes, or respires—*i.e.*, its unstable substance is constantly wasting, with elimination of carbon dioxide (CO_2) as a product of waste, and intake of oxygen (O), by which such waste is promoted. The necessity for this process lies in the fact that it renders available a certain amount of energy for the execution of movements, etc. Were there no counterbalancing process the free oxygen of the air would rapidly diminish in amount, and the quantity of carbon dioxide correspondingly increase, until in the end every living thing would die of suffocation.

Green plants, however, as elsewhere explained, use (with the aid of sunlight) carbon dioxide as an important part of their food, and thus prevent accumulation of this deleterious compound. And further, as a by-product of their nutritive processes, they give out large quantities of free oxygen, the supply of which, in the air, is thus maintained. The proportion between supply and demand is so nicely balanced that the composition of the atmosphere would appear to remain practically the same for indefinite periods of time. But if such balance is to be kept up it is clear that the proportion between the sum-totals of plant and animal life must remain steady.

Feeding. Since living substance is constantly undergoing waste it must as constantly renew itself to a corresponding amount, or do more than this if growth and increase are to take place. Hence the necessity for *food*, which furnishes the building material. In the case of animals this is of complex chemical nature, and is directly or indirectly derived from green plants, which alone are able to construct living substance from simple inorganic compounds. Putting it broadly, we may say that without such plants the animal world would either suffocate or starve, or both.

Every Animal the Solution of a Problem. Every kind of animal (or plant) has come into existence by the modification of some pre-existing kind—*i.e.*, has been *evolved*. It may be regarded as the solution of a problem, this being how to get a living in particular surroundings (in a special *environment*) under stress of competition, which has often been acute. The unsuccessful solutions have paid the penalty by becoming extinct. Success is bound up with all sorts of structural alterations, tending in various directions, such as better arrangements for securing food, for defence, for breathing, for propagation, and so on.

Effect of a Changing Environment. The surroundings of animals are changing more or less rapidly, and hence the necessity for a continuance of the process of evolution. As soon as a successful solution of the problem is attained—nay, while it is being attained—the essentials of success have altered. And we may say that every complex kind of animal corresponds to the sum of a series of solutions of a long succession of problems.

In all animals belonging to the higher groups we find waning structures which are in process of reduction, because they no longer fulfil their original purpose. They are, in fact, the remains or *vestiges* of organs which have, so to speak, lost their work, the survivals of successful solutions to problems presented by earlier conditions. A whale, for example, has no visible hind-limbs, but vestiges of them may be found on dissection. These are, no doubt, the dwindled remnants of extremities that were well developed in remote terrestrial ancestors. Another good example is afforded by the insects of Kerguelen Island, in which the wings have been reduced to useless remnants. The winds are so strong in this part of the world that, for insects, the power of flight would be a positive disadvantage, as its possessor would probably be blown out to sea and perish.

Change of Function. Organs which are thrown out of work by changes in surrounding conditions often undertake new functions, and thereby escape being reduced to vestiges or disappearing altogether. Fishes, for example, commonly possess a swim-bladder, which has to do with balancing the body in the water at different levels. Land animals, which have undoubtedly arisen from fish-like ancestors, have obviously no use for an organ of this kind, and there is good reason to think that in their case the swim-bladder has become modified into lungs, by which the gills have been superseded.

The fact that an organ, at its first inception, may not perform the functions it ultimately discharges disposes of one objection to the theory of evolution—*i.e.*, that it is difficult to imagine how some organs have arisen, seeing that they would be useless for a particular purpose in the earlier stages of their development. Wings have been adduced in support of this contention. Wings, however, were probably at first merely parachuting organs, affording an extension of surface which would be useful even if only of small amount.

Homology and Analogy. Organs which develop in a similar way, and have equivalent structural relations, are said to be *homologous*, or to display *homology*, irrespective of the uses to which they are put. That such uses may be different will be realised in the light of what has been said about change of function. We know, for example, that the "drum" of the ear in ourselves, a cavity that has to do with the conduction of sound-waves to the internal organs of hearing, is represented in some fishes by the most anterior gill-cleft, which plays a part in breathing.

Analogous organs, on the other hand—structures which display *analogy*—have similar functions, whatever their actual anatomical relations may be. The wings of birds and insects are in this way equivalent, for they both are used in flight, though their nature is utterly different.

Of course, some structures may be both homologous and analogous, such as the eyes of fishes, reptiles, birds, and mammals.

The principles enumerated will be frequently referred to in the sequel, where we shall have to deal with all sorts of adaptations to surroundings of different nature. Every great group of animals is constructed on a common plan, but this will present all sorts of modifications according to the uses to which it is put.

CLASSIFICATION OF ANIMALS

The whole of the animal world may be divided into a comparatively small number of large groups, or *phyla*, the most important of which are as follows:

Phylum 1. Backboned Animals

(*Vertebrata*)

The highest animals are here included, and are distinguished by the possession of a backbone (or its equivalent), a hollow, dorsal, central nervous system, and gill-clefts, which are always present during part of the life-history, though in the highest classes of the phylum they have nothing to do with breathing. For details, reference may be made to the course on BIOLOGY, which also summarises the ways in which backboned animals differ from other forms that are collectively called Backboneless Animals (Invertebrata), a convenient though not very scientific term.

Phylum 2. Shell-fish

(*Mollusca*)

These include cuttle-fishes and their allies, snails and slugs, and bivalve molluscs (oysters, cockles, etc.), in which the body is not divided into rings or segments, has a fleshy locomotor organ, or *foot*, projecting from the under side of the body, and usually an external shell.

Phylum 3. Jointed-limbed Animals

(*Arthropoda*)

This group embraces insects, scorpions and spiders, centipedes and millipedes, and crustaceans (lobsters, crabs, shrimps, prawns, etc.). In all of these the body is segmented, or divided into rings, or segments, of which a varying number bear jointed limbs. There is a horny external skeleton, sometimes strengthened by calcareous matter, as in most crustaceans.

Phylum 4. Ringed Worms

(*Annelida*)

This group includes a vast number of marine worms, as well as earth-worms and leeches. Their bodies are segmented, and in marine worms the segments are provided with stump-like limbs, never divided into joints.

Phylum 5. Lamp-shells and Moss-polypes (*Molluscoida*)

Lamp-shells appear to be distant and specialised relatives of the ringed worms, and possess a bivalve shell, which differs, however, from that of bivalve molluscs. They are marine, as also are most of the moss-polypes, minute creatures that are nearly always aggregated into variously shaped colonies.

Phylum 6. Wheel Animalcules

(*Rotifera*)

These are very small, transparent creatures, of doubtful affinities, which abound both in salt and fresh water, and are among the most attractive of microscopic objects.

Phylum 7. Round Worms

(*Nemathelmia*)

Here are placed numerous rounded, unsegmented worms, many of which are parasitic, and may have a complex life-history.

Phylum 8. Flat Worms

(*Platyhelmia*)

Most of the members of this group are flattened, unsegmented parasites—*e.g.*, tapeworms and flukes. They are chiefly notable as being a source of disease, while their life-history is often exceedingly complex.

Phylum 9. Hedgehog-skinned Animals (*Echinoderma*)

This phylum is very clearly defined, and includes a large number of purely marine animals, of which star-fishes and sea-urchins are most commonly known. In the members of the preceding phyla the body is *bilaterally symmetrical—i.e.*, divisible into right and left halves, with a clear distinction between anterior and posterior ends, while the upper and under surfaces are more or less unlike each other. But in star-fishes and their allies, although the same kind of symmetry is traceable, it is more or less obscured by radial symmetry—a kind of regularity such as is seen in a wheel, star, or regular flower. The skin is strengthened by calcareous plates, which often bear spines.

Phylum 10. Zoophytes

(*Cœlenterata*)

Probably the most familiar members of this phylum are the beautifully-coloured sea-anemones, which are to be found sticking to rocks between tide-marks, and when fully expanded well deserve their name of "sea flowers." Such an animal is essentially a living stomach, radially symmetrical, with circlets of tentacles surrounding a central mouth. Corals and jelly-fishes are other examples of the group. Nearly all zoophytes are marine, and a large number are in colonies.

Phylum 11. Sponges

(*Porifera*)

A simple sponge is a vase-shaped structure, with its walls perforated by numerous canals, into which flow currents of water bearing food and oxygen. The various products of waste are borne away by a stream that makes its exit from the mouth of the vase. Most sponges, however, form colonies of various and often irregular shapes. There is usually a calcareous, flinty, or horny skeleton, a good example of the last being afforded by the bath sponge. With few exceptions, the members of the group are marine.

Clarke & Hyde

239. GREAT ANT-EATER

Phylum 12. Animalcules

(*Protozoa*)

This phylum embraces a host of lowly animals, the vast majority of which are minute or microscopic, and often difficult to distinguish from the lowest plants. The body of an animalcule consists of a single cell only, but this may be of very complex character. Some of the slimy "oozes" which cover vast areas of the ocean floor are mainly composed of the calcareous, or flinty, skeletons of creatures of the kind.

Taking these twelve great groups of the animal kingdom in order, beginning with the highest, we shall be able to illustrate abundantly the main principles of Zoology, the chief difficulty lying in the great wealth of material.

BACKBONED ANIMALS

(*Vertebrata*)

This large division of the animal kingdom is subdivided into the following classes [see BIOLOGY]: 1, Mammals (*Mammalia*); 2, Birds (*Aves*); 3, Reptiles (*Reptilia*); 4, Amphibians (*Amphibia*); 5, Fishes (*Pisces*); 6, Border vertebrates (*Protochorda*).

Mammals (*Mammalia*). To this class belong all the familiar warm-blooded quadrupeds, together with certain specialised aquatic forms—*e.g.*, whales, which are popularly, but erroneously, regarded as fishes. All mammals breathe ordinary air by means of lungs, and never at any time possess gills. They are more or less clothed with hair, and their young are nourished for some time upon milk.

The orders or groups of mammals are as follow:

Order 1. Men and Monkeys

(*Primates*)

All the members of this order are distinguished by the possession of a relatively large brain, and this affects the general shape of the skull, one result being that the eyes are directed to the front. Man alone excepted, these highest mammals are adapted for a climbing, tree life, and their feet are grasping organs.

MAN-LIKE APES. These approach more nearly to man in structure than the other members of the order, and, unlike these, can walk on their hind limbs with more or less facility. The gorilla and chimpanzee [230] are native to tropical Africa, the orang-utan to Sumatra and Borneo, and the gibbons to south-east Asia. These, and the very numerous monkeys of the Old World, have comparatively narrow noses, thus differing from the broad-nosed monkeys of America, many of which also possess prehensile tails. In the latter group, too, are included the little marmosets.

Order 2. Lemurs

(*Lemuroidea*)

These are small monkey-like creatures included by some authorities in the last order, but decidedly lower in the scale. They inhabit the tropical forests of the Old World, most of them being peculiar to Madagascar.

Order 3. Insect-eaters

(*Insectivora*)

The members of this large and ancient order are small animals found more or less in nearly all parts of the world, and adapted by their structure to feed upon insects and other small creatures. Of British species, the hedgehog [231], mole, and shrew, belong here.

Order 4. Bats

(*Chiroptera*)

These are closely related to the insect-eaters, from which they differ in the possession of organs of flight [232]. The larger bats of the East Indies are fruit-eaters.

240. KANGAROOS

Reid

Order 5. Gnawers

(*Rodentia*)

Here, again, we have a large, ancient, and widely distributed order, including animals that are mostly small, and generally adapted for living upon vegetable food, though some are omnivorous. They possess four chisel-edged front teeth (incisors), which grow continuously throughout life. Of familiar British types, rabbits, hares, voles, rats, mice, and squirrels illustrate the wide variations in habit that characterise the order.

Order 6. Hoofed Mammals
(*Ungulata*)

This group includes most of the large herbivorous forms, as well as a few omnivorous ones, and the hoofed extremities are more or less adapted for swift progression. The odd-toed and even-toed ungulates are respectively distinguished by an odd and even number of digits on the hind foot.

Odd-toed Ungulates. The pig-like tapirs of south-east Asia and South America possess four toes on the fore and three on the hind foot, while the rhinoceroses [233] of Africa and South Asia have only three on each. In horses and their allies there is but one large toe on each foot.

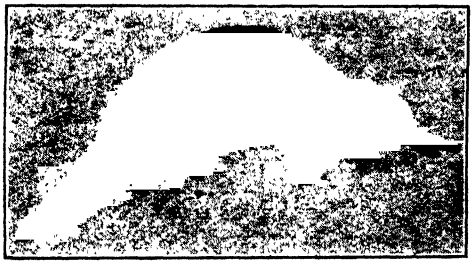
Even-toed Ungulates. The omnivorous swine and the plant-eating hippopotamus of Africa [234] do not chew the cud, and thus differ from the ruminants, among which are included deer, oxen, sheep, goats, giraffes [235], camels, and llamas.

Order 7. Elephants
(*Proboscidea*)

These huge plant-eaters, native to Africa and South Asia, are in many ways simpler in structure than the members of the last order, but their teeth are much specialised, and the prehensile trunk, into which the snout is drawn out, is a notable peculiarity [236].

Order 8 Sea-cows
(*Sirenia*)

This group of plant-eating marine mammals is represented only by the dugong and manatee, which haunt the shores and estuaries of the Indian Ocean and South Atlantic respectively. The tail is horizontally flattened, the fore limbs are modified into flippers, and the hind limbs have disappeared entirely.



Kent

241. DUCK-BILLED PLATYPUS

Order 9. Whales and Porpoises
(*Cetacea*)

These are still more fully adapted to an aquatic life than are the sea-cows. Some, such as the porpoise and sperm-whale, possess numerous pointed simple teeth, while the whalebone whale and its allies are entirely toothless.

Order 10. Flesh-eaters
(*Carnivora*)

Here are included a great variety of predaceous forms, possessed of strong tusks, or canines, cutting back teeth, and clawed digits.

The Cat Family (*Felidæ*) embraces the species best adapted for a carnivorous life, such as the lion [237] of Africa and India, the tiger of Asia, and so on. The hyænas of the Old World make up a closely related group.

The Dog Family (*Canidæ*) includes dogs, wolves, foxes, and jackals, which are not so specialised as the foregoing.

The Weasel Family (*Mustelidæ*) is represented by many small blood-thirsty forms, such as weasels, and by the larger otters, which are equally rapacious. The omnivorous badgers also find a place here.

The Bear Family (*Ursidæ*). With the exception of the Polar bear, the members of this family are omnivorous, and less specialised in structure than most other flesh-eaters [238].

Aquatic Flesh-eaters (*Pinnipedia*). These are the walruses, sea-lions, and seals, all of which are well adapted to a marine life, as may be seen by their shape and the flipper-like nature of their extremities.

Order 11. Mammals Poor in Teeth
(*Edentata*)

Living in South America are a number of archaic forms, which are the chief living examples of this decadent order, that is also represented, however, in the Old World. They include the toothless great ant-eater [239], the burrowing and armoured armadilloes, and the leaf-eating arboreal sloths.

Order 12. Pouched Mammals
(*Marsupialia*)

Except the American opossums, the members of this primitive order are natives of the Australian region, where, in the absence of competing higher types, they have acquired an extraordinary diversity of character, adapting themselves to the most varied habits. The native " wolf " for instance, is a flesh-eater; the banded ant-eaters are insectivorous; the little pouched mole feeds on various small creatures; the springing kangaroos [240] are herbivorous; the burrowing wombat devours roots, and the climbing phalangers eat fruit. The young of marsupials are born in a very immature condition, and are sheltered for some time in a pouch formed by a fold of skin on the underside of the mother's body.

Order 13. Egg-laying Mammals
(*Monotremata*)

This order includes only the duck-billed platypus [241] and spiny ant-eaters of Australia, which are much more primitive in structure than any other existing mammals, and present many points of resemblance to reptiles. The most extraordinary fact in regard to them is that they lay eggs, though the young, when hatched, are fed on milk, as in the other orders. The milk-glands, however, are devoid of teats, and their secretion oozes into a depression, from which it is licked up.

Continued

continued from page 1410

MISCELLANEOUS POSTS

Officers in Public Libraries, Asylums, Washhouses, Parks, and Gardens. The Fire Brigade. Lighthouse Keepers. Tramway Employees. Hall Keepers

By ERNEST A. CARR

IN addition to educational and Poor Law appointments, which are reserved for special consideration, there remain several of the Municipal Service departments that may conveniently be included within the scope of a single article. Of these the most notable are the public libraries, asylums, parks and gardens, the fire brigades, the municipal tramways, and the lighthouse service of Trinity House.

Mention may be made also of the appointment of coroner—a valuable office, commanding a salary (or equivalent fees) varying between £400 and £1,200 a year. This post is within the disposal of the borough or county authority, but as it is always reserved for a legal or medical expert of established position and wide experience, no useful purpose could be served by discussing it further in these columns.

Public Libraries. The most diverse views prevail among borough councils as to the remuneration of library officials. Fairly valuable appointments are sometimes made in this service; but, on the whole, it cannot be said to be liberally rewarded. A municipal librarian who is perhaps the most eminent member of the service expresses his opinion on this question with the utmost force. "I should think there is no doubt whatever," he writes, "that, as a class, librarians are not adequately remunerated. It is indeed a simple truth to say that librarians as a body are among the worst remunerated officials in the service of municipalities. This is due very largely to the limitation of the library rate." On the one hand, the Guildhall librarian (who is a well-known antiquarian and scholar) receives £850 a year, the chief librarian of Manchester £500, and his colleague at St. Pancras £350, rising to £500. On the other hand, £80 a year was lately offered at Hanwell for an "experienced and qualified" librarian, and the Taunton Council invited applications from trained officials between 28 and 45 years of age for a head position at £100 a year, without residence.

Such instances are not altogether exceptional, the obvious explanation being that, in the rank and file at least, the libraries service calls for no special qualifications. Fair abilities and education, a gentlemanly address, and some previous experience—these comprise the usual requirements for minor positions, and the competition among young men thus equipped is so great that, in accordance with the laws of supply and demand, salaries rule low.

The service is chiefly recruited by youths entering either as evening assistants at a few shillings weekly, or, more generally, on a full-time footing as junior assistants at £25 or £30 a year, rising to perhaps double their initial salary. On promotion to senior grades their earnings, starting at £70 or £80 a year, will reach £100, £120, or £150, the last figure being seldom exceeded for auxiliary posts. The next step—either a branch librarianship or a small independent command—may mean but a slight advance in salary, the average range for such an appointment being from £120 to £180 a year, with or without rooms. Its importance to the young official lies in the chance thus afforded him of proving what mettle is in him—his judgment, organising skill, and general fitness for the responsibility of a principal position.

Leading appointments, as already indicated, are very variously repaid. In the borough of Wandsworth, possessing four important public libraries, the principal librarian receives £350 a year, with residence, light, and fire, and the three other officers in charge, £250, £230, and £150 respectively, with similar emoluments. The following stipends are paid to chief librarians in other London boroughs: Greenwich, £150, rising by £10 yearly to £200, with quarters, light, and fuel; Fulham, £200, rising to £275; Islington, £300; Deptford, £200.

Ladies as Librarians. The libraries service affords a field of fairly well-paid employment for women, many of whom are engaged by local authorities in subordinate positions. The rate of remuneration for lady librarians is generally less than for their masculine colleagues, junior assistants receiving from £20 to £40 yearly, and seniors, £50 to £80. Manchester has placed four of its branch libraries in charge of ladies, with salaries ranging from £70 to £95 a year; and in the libraries of several London boroughs a small female staff is employed at similar rates.

The Library Association. With the object of improving the qualifications and status of librarians as a class, an important organisation has been formed among members of the service, under the title of the Library Association, having its headquarters at Whitcomb House, Whitcomb Street, Pall Mall, London, S.W. Its educational work is carried out in conjunction with the London School of Economics, and consists of the special training of assistant librarians and other students who are seeking proficiency in library work, with a view to qualifying for responsible posts. Lectures are given on the various special duties of librarians, and examinations are held periodically, on the results of which certificates are awarded to successful candidates. A series of certificates entitles the student to the diploma of the Association—a qualification which in itself should add materially to the diplomate's chance of securing a leading position.

Asylum Officials. Apart from medical billets (which have already been discussed on page 699), municipal asylums furnish employment to a large staff of stewards, matrons, and subordinate officers. These posts are variously filled, some authorities advertising vacancies and others adopting the system of a "waiting list." Candidates for service under a particular council should, therefore, ascertain from the clerk which of these methods is adopted.

The Asylums Committee of the London County Council, which controls ten large asylums and may be taken as a typical authority, remunerates its officers on the following scale, an annual increment, up to the maximum salary, being given in every grade.

Steward, £300, rising by £20 to £400, with a house.

Storekeeper, £200 to £250.

Clerk, £200 to £350.

Assistant clerk, £100 to £150.

Dispenser, £110 to £160.

Matron, £100 to £150.

These officers, except stewards, advance by £10 yearly.

Assistant matron (second class), £60, by £2 to £70; first class, £80 to £90.

Male attendant (second class), £29 to £35; first class, £36 to £43; head officer, £50 to £66.

Female attendant, in corresponding classes, £18 to £24, £25 to £33, and £40 to £50.

Farm bailiff, £2 2s. to £2 10s weekly, with a house.

Tailor and other workmen, 30s. to 38s.

Male cook, £60 to £70.

Butcher, £52 to £60.

Gardener, 25s. to 30s., and a cottage, or 5s. extra instead.

In addition to their salaries, storekeepers, cooks, and butchers are provided with meals free of charge, and clerks and dispensers with dinner only. Matrons of each class receive board, lodging, and washing, and attendants the same advantages, with their uniforms, and £2 a year good-conduct money besides.

In connection with this service, it should be noted that the posts of steward and storekeeper are generally filled by the promotion of asylum clerks, and that of matron from the assistants. Candidates for assistant clerkships are required to have some knowledge of accounts and to understand the receipt and issue of stores. The higher grades of attendant are invariably recruited from the subordinate ranks. It is the Council's general practice to appoint second-class attendants from a list of suitable applicants, the age limit prescribed for men being 35 years or less, and for women 20 to 30 years. Preference is given to male candidates who are instrumentalists, or who can play cricket and football, and to women with a knowledge of music and singing. Dispensers should hold the minor certificate of the Pharmaceutical Society. A liberal pension scheme is in force for officers of all ranks.

Municipal hospitals are staffed in practically the same way as asylums, except that the attendants are replaced by a corresponding number of nurses. These officers, if admitted as probationers, receive from £15 to £24 yearly during training, and afterwards £35 to £45, in each case with full allowances in addition.

Baths and Washhouses. During recent years, many local authorities have realised the urgent need for promoting cleanliness—both personal and domestic—in their districts. One result of this awakening is manifest in the numerous and well-appointed public baths and washhouses owned by municipal bodies in every part of the country. These buildings—some of which contain elaborate and costly apparatus for vapour, electric, and medical baths—are generally placed in charge of a superintendent, with or without the aid of a matron.

The position of baths superintendent is a responsible one, requiring a sound practical knowledge of hydraulic and heating apparatus, as well as good organising powers. A recent advertisement of such a vacancy stated that "Candidates must be thoroughly competent to take charge of the building and machinery, and those whose qualifications include a knowledge of engineering will receive special consideration." In this, as in many other instances, it was stipulated that applicants must be not more than forty years of age. The value of these posts may be best shown by a few typical cases. In addition to residence, coal and fuel, the superintendent of baths for Manchester receives £300 a year; at Westminster, £250 (advancing to £300); at Battersea, £200; and at Kensington, £130, rising to £160. The superintendent and matron of the Wandsworth baths receive a joint salary of £160, with the usual allowances. Corporations owning several public baths often place an expert *masseur* and bath attendant in charge of each as manager, under the general control of the superintendent, at a stipend of £120 or £150 a year. For attendants and shampooers, the customary rate of pay in municipal baths is 30s. to 40s. a week.

Parks and Gardens. The foremost municipal owner of open spaces is probably the London County Council. That authority can boast of 106 pleasure grounds, covering 4,920 acres, for the care of which a permanent staff of 880 men is employed. Efficiency is encouraged in the L.C.C. service by filling all the higher posts by promotion. Applicants are admitted either as gardeners at 28s. a week, or as constables, labourers, or under-keepers, at 27s. From their ranks selections are made for the respective superior grades of propagators, sergeants, and keepers, and so up to the highest position attainable—that of park superintendent, at a maximum salary of £225 a year, with a house, gas, and water free. Candidates, who must be between 25 and 40 years of age, may obtain application forms and further particulars from the Parks Department, 11, Regent Street, London, S.W. For gardeners, the Royal Horticultural Society's certificate in practical horticulture is a recommendation.

Save that in provincial areas the average of salaries is somewhat lower than in London, this example will serve to illustrate the general conditions of service in municipal gardens and cemeteries throughout the country.

It may be mentioned, however, that the post of general superintendent of parks (worth in the larger boroughs from £250 to £450 a year) is usually to be reached by direct promotion, which is not the case in London; and that a clerical registrar is appointed to each cemetery, at a salary averaging £250 a year.

Fire Brigade Posts. The conditions of service probably vary more widely, according to the district, in this than in any other branch of local government work. Under the smaller councils, the fire brigade is either an amateur corps, or at best a volunteer company receiving some such casual remuneration as a shilling for every hour of actual duty at fires. In larger areas it may comprise a small staff of salaried officers, reinforced by volunteers in time of need. Many borough councils regard it as a branch of police duty, appointing a special section of their force to act as firemen. This is the case, as we saw, with the Liverpool Constabulary, which includes a smart and well-equipped fire contingent. Finally, as in London, Manchester, and other leading towns, the fire brigade is a large and distinct force.

The London Fire Brigade. The title of this famous body, long known and admired of Londoners as the Metropolitan Fire Brigade—or more familiarly as the "M.F.B."—has lately been altered by Act of Parliament, for cogent reasons which one yet cannot help regretting on sentimental grounds, to that which heads the present paragraph. The London Fire Brigade, the very type and model of an efficient service, is controlled by the County Council for the capital, and supported mainly by the rates, in part from the contributions of fire insurance companies, and to some small extent by a Government grant. It is, therefore, in essence a municipal body, and as the largest fire force in the Kingdom, numbering 1,300 of all ranks, it offers the widest scope to would-be recruits. For these reasons, its conditions of entrance and service merit our special notice.

Candidates for entrance into this small civil army, either as firemen or coachmen, should apply personally at the brigade headquarters, in Southwark Bridge Road, at 9 o'clock on any Friday morning. Recruits are carefully chosen under the following conditions. They must be smart, strong, active men, of good character and education, between 21 and 31 years of age, at least 5 feet 5 inches in height, and 37 inches round the chest. Married men are rarely accepted for either branch. As far as possible, preference is given to London candidates. For firemen, service in the Navy or the mercantile marine is an almost essential qualification.

Payment of Firemen. Applicants who satisfy these conditions, on passing a medical examination and a test of strength, are admitted as probationers, and undergo a course of instruction that lasts about three months, receiving 24s. a week meantime.

The pay of firemen on appointment is 26s. a week, and rises to 37s. 6d. Coachmen, who form but a small proportion of the staff, begin at 24s. and rise to 31s. 6d. a week. Uniform is, in either grade, provided free of charge. There are about 100 superior posts in the Brigade, as station officers, district officers, and superintendents, with salaries ranging from £130 to £245 a year, all of which are filled by promotion from the ranks. Lastly, that the fireman may face the risks of his calling without undue anxiety for those dependent on him, there is a liberal scheme in force of gratuities and pensions for officers, and allowances to their widows and children.

In provincial brigades, the initial pay of officers is about the same as in London, but the higher posts are not so well rewarded. Manchester pays its chief fire officer £350 a year, and his lieutenant £200; but, except in towns of such leading rank, the superintendent—who, as responsible officer, must have administrative capacity as well as practical experience—seldom receives more than £150 to £180, with quarters, light, and fuel. The lower figure was lately offered, not only at Swindon and Edmonton, but even by so important a county borough as Croydon.

The Coastwise Lights. The lighthouse service of England and Wales is under the jurisdiction of that quaint and ancient "Corporation of the Trinity House at Deptford Strond," which now has its headquarters on Tower Hill. The Trinity House is a foundation of unknown antiquity, that was already a flourishing institution when the eighth Harry granted it, in 1514, its earliest Royal charter. In addition to controlling the lighthouses and lightships of the coast, the Corporation is entrusted with the management of the general buoyage system, and the removal of dangerous wrecks around our shore. For the execution of these duties, a large staff of officers is employed in the lighthouses, lightships, and steam vessels of the Corporation. The strength of each branch is approximately as follows. Lighthouse keepers 200 to 250; light-vessels staff, 550, and steam vessels, 150 men, excluding officers. The conditions of entry into this service, and the rates of pay obtaining in it, are as follows:

Lighthouse Keepers. Candidates must be between the ages of 19 and 28, and unmarried. They are required to produce certificates of birth, health, character, and education—the last requirement comprising reading, writing from dictation, and a fair knowledge of arithmetic. In the selection of men for employment preference is given to artisans and sailors. On entering the service, officers are classed as supernumeraries and are paid 2s. 6d. a day. When qualified for appointment to a lighthouse as assistant keepers, they receive 3s. a day, with dwellings, coal, and light (or a money allowance in lieu thereof), and their uniform, and are entitled to medical attendance at a nominal charge. Their daily pay increases by gradual increments to 4s. 2d., the maximum pay of a principal keeper. By a wise provision the life of every keeper is insured by the Trinity

House for the benefit of those who may be dependent on him. For this purpose the Corporation pays a fixed annual premium of £3, the value of the policy depending on the officer's age on entering the service.

For the light-vessel and steam-vessel branches, applicants must be seamen under the age of 32, and must provide certificates of birth, character, and sea service in the A.B. class. A member of the crew of a lightship receives 4s. 1d. a day on entry, rising through various grades to 6s. 1d., the maximum pay of a master. On the steam-vessels the rate of pay for seamen starts at 4s. 4d. and rises to 5s. 8d. a day, the maximum wages of carpenters. Officers in the steam-vessel branch are appointed from those who have been apprenticed to the service as youths. Vacancies for such apprentices are not frequent. In either branch the seaman's uniform is furnished free, but every man has to provide his own food. After three years' service the life of each seaman is insured.

Men in the lightship service are afloat for two months at a spell, and are then allowed a month ashore. During the shore turn, however, they must report themselves for duty at the district depôt, and are occasionally required to form part of the crew of the district steamer, in which case they receive extra pay. Masters and mates of light-vessels spend alternate months afloat and ashore.

Officers of the Trinity House are granted pensions proportionate to their service, 40 years' duty entitling them to the maximum allowance of two-thirds pay.

The Tramways Service. There are some 14 municipal tramways in Great Britain, conveying every year over their 1,150 miles of metals more than 1,000,000,000 passengers. Employment is thus afforded to a huge industrial army, on terms which are generally more liberal —in respect alike of higher wages and shorter hours—than those exacted by private companies. The Tramways Department of the London County Council, which is only rivalled in size by that of the Glasgow Corporation, numbers 3,500 workers, from general manager to trace-boy. Apart from administrative officers, its employees are remunerated at the following typical rates: Drivers and conductors, mechanical or horsed cars, 4s. 9d. a day; after six months, or on obtaining a service, 5s. 3d.; 5s. 9d. after six months on a service, and at the end of another half-year the maximum rate of 6s. 3d. a day. An overcoat, uniform coat, and two caps are allowed yearly.

Foremen, £2 to £3 10s. a week.
Regulators, £2 2s. to £2 4s.
Ticket Inspectors, £2 2s.
Night Inspectors, £1 10s. to £2 2s.
Point fitters, £1 15s.
Horsekeepers, £1 6s. to £1 9s

There are also a number of car washers, track cleaners, and point shifters, earning between £1 and £1 10s. a week; as well as carmen, permanent-way men, and labourers, at standard rates of pay.

Vacancies in the municipal yards are usually filled by the Chief Officer of Tramways. In the case of the L.C.C., applications for employment should be addressed to that official at 303, Camberwell New Road, S.E.

Hall-Keepers. According to the nature of the duties exacted, the remuneration of the town-hall keeper generally varies between 30s. a week and double that sum—always with residence, coals, light, and uniform. Yet, modest as it is in position and in official rewards, this post is eagerly contested whenever a vacancy is announced, for it is an open secret in the municipal world that a hall-keeper's extra earnings often equal his salary, and are sometimes far in excess of it. Receptions, civic balls, and other functions bring rich *largesse* to the official in charge. When a London appointment of this class, with a stipend of £2 a week, was recently advertised, its actual value was computed by those who should know as between £350 and £400 a year.

Beyond fixing an upper age limit of 45 or 50, and stipulating sometimes for the absence of "encumbrances," the qualifications of hall-keepers are rarely prescribed. Those which commend themselves most to the appointing authorities are good organising powers, smartness and method, previous experience, regularity of habits, and a fair degree of education.

Gas Meter Inspectors and Water Experts. Among the smaller departments of local government work may be mentioned the inspection of gas meters and of water fittings. In London the former service is recruited by appointing applicants whose names are on the council's books to the grade of assistant or clerk. Assistants receive 25s. a week, rising to 30s., and on becoming resident assistants they advance by 2s. a week yearly to 50s. a week, with lodgings, coal, and gas. Gas meter clerks rise by £5 yearly from £100 to £150 a year. From these two classes promotions are made to the rank of gas meter inspector (£135 to £175), and chief inspector (£200 to £300). In the larger provincial towns the gas-meter testing department is variously organised, but the posts attainable in it are approximately of the same value as in London. Water inspectors are practical experts employed by all corporations with a municipal water supply, their duties consisting chiefly of the examination of service fittings and the detection of leakage and waste. They are paid from 35s. to £2 5s. a week or more, with chances of promotion to the position of chief inspector, with a salary of £250 or £300 a year.

Messengers, Caretakers, and Porters. Municipal messengers, caretakers, and porters, as they differ in no wise from their colleagues outside the public service, need occupy but very few words. They are generally appointed from "waiting lists" kept by the council's clerk. Applicants possessing such modest qualifications as these posts require should, therefore, secure the addition of their names to the queue of "suitable persons." This list, however, is usually a long one, for the public service, like all others, is most crowded at the foot.

Continued

Continued from page 1358

THE SHAPING OF THE LAND

How the Surface of the Earth's Crust is Moulded by the Agencies of Wind, Rain, and Underground Water

By W. E. GARRETT FISHER

WE have now seen how the rocks have been solidified from their original liquid condition in the great subterranean laboratory We have next to embark upon the larger, and, in some ways, more interesting, consideration of how they have been changed and moulded on the surface of the earth. The present condition of the world, with its mountain ranges and river valleys, its broad seas and fertile plains, is mainly due to the work of the agencies to which we shall now give attention.

The following table presents, in a convenient form for reference, the *epigene*, or *superficial forces*, which have thus modified our planet :

1. Aerial Forces.
    - (*a*) Wind
    - (*b*) Weather
    - (*c*) Changes of temperature
2. Aqueous Forces.
    - (*a*) Rain, hail, and snow
    - (*b*) Underground water
    - (*c*) Running water
    - (*d*) The sea
    - (*e*) Ice
3. Organic Forces.
    - (*a*) Plants
    - (*b*) Animals
    - (*c*) Man

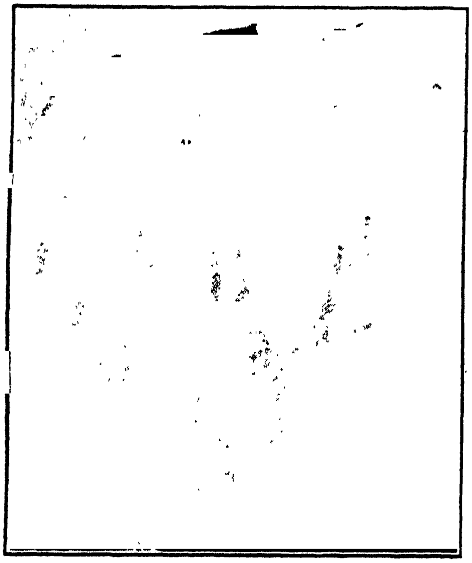
Those agencies are very simple and natural forces, with which we are all perfectly familiar. They are the forces, in short, of *air*, *water*, and *life*. It is one or other of these three forces to which is due the change of the earth from a barren and fire-swept globe of volcanic rock, upon which no kind of life was possible, to the hospitable and fertile planet which we now inhabit.

The Atmosphere. We shall first consider the geological work of the atmosphere. We are accustomed to think of the air as a yielding and impalpable substance, so that it is not easy to realise at first the immense quantity of work which it has done in modifying the face of the earth. We know, however, that air, invisible and subtle as it is, when put into rapid motion, is capable of very destructive effects. The destruction of human property which is occasionally caused by a cyclone or tornado on land, and the wrecks which strew our shores after every storm, alike bear witness to that. The geological effects of wind, which is simply air in motion, have thus to be reckoned with.

The Work of Wind. We can readily see that one of the most important of these effects is the *transportation of matter* from one place to another. The tendency of other natural forces, as we shall see presently, is to wear down the rocks into fine dust or sand. The wind is capable of transporting this fine material for long distances, and not infrequently heaps it up into great masses. Most of the sand dunes [48] which line the seashore in so many parts of the world are simply wind-drifts, which have been pinned down and preserved in a more or less durable form by the growth of wiry grasses and other kinds of vegetation.

48. SAND DUNE, WEST OF BOURNEMOUTH, FORMED BY WIND ACTION

That these sandhills are entirely due to wind-drift is clear from the ripple marks which are observable on blown sand, and from the general shape of the sandhills themselves. In the interior of the Asiatic and African continents are found vast tracts of sandy desert, in which the wind has undoubtedly been the main agent in spreading the detritus of the original rocks over vast areas. In the desert of Gobi many ancient cities have been buried deep beneath the steady and inexorable march of the wind-driven sand. The great desert of the Sahara is believed to owe its present extent and nature largely, if not entirely, to the action of the wind.



49. FACE OF THE SPHINX, SHOWING EROSION BY SAND-LADEN WIND

Blood-rain. The transporting action of wind sometimes covers an almost incredible area. The well-known phenomenon of *blood-rain* is a case in point. The sand of the African desert is raised into the upper regions of the air by local winds, and there meets with the strong and persistent aerial currents which carry it away for scores or hundreds of miles. It is often known to reach the countries on the northern side of the Mediterranean, where its presence is indicated by the fall of rain-showers tinged to a deep red colour by this desert sand, and popularly called blood-rain. The sand of the Sahara is said to have been detected as far away as Boulogne ; and in 1901 it was estimated that a vast quantity of sand was transported by wind from Algeria as far as Russia.

Loess. A remarkable deposit, known as *loess*, which is found in many parts of Northern China, covering considerable tracts of ground to a thickness of one or two thousand feet, is believed to be entirely a wind formation. It is a yellowish clay, or loam, and consists chiefly of hydrated silicate of alumina. It contains numerous organic remains, which are mainly of terrestrial origin. This loess forms an extremely fertile soil, and plays an important part in the agriculture of China. It is found filling river valleys, and high up among the hills, in such a position that it is practically impossible to suppose that its site was once inundated by water, and that it was deposited in the form of what we call alluvial soil, which it resembles in other characters. It is almost certain that the loess is the consolidated dust once drifted by the wind from the great plains of Central Asia, which has gradually hardened and accumulated into these vast deposits.

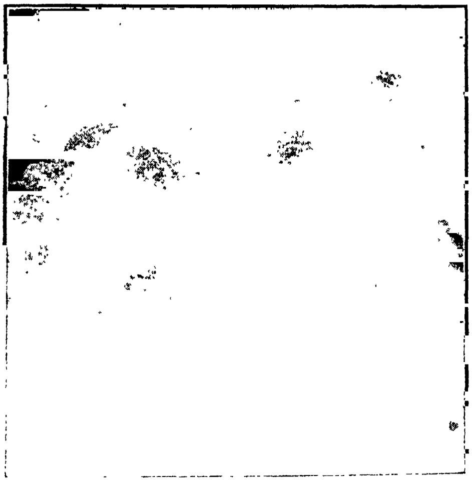
Transport of Life by Wind. The wind is also capable of transporting the minuter forms of life from place to place. These tiny organisms, which are no larger than ordinary grains of sand, are carried on the wings of the wind for vast distances, and find new homes for themselves when at last they descend to the earth. In this way similar forms of life are found occupying districts very widely separated. There are also well-authenticated instances of the transport by wind of larger organisms than mere seeds or spores. Sometimes a whirlwind or tornado has been known to carry fish in its embrace for many miles, though the showers of frogs, of which one hears every spring in the country, are generally to be received with scepticism.

Weathering of Rocks. The atmosphere not only transports soil from one place to another, and thus modifies the nature and contour of the earth's surface : it also has a considerable effect in breaking down the hard rocks into dust suitable for such transport. These destructive effects are partly *chemical* and partly *mechanical*. In the first place, rocks are subject everywhere to the operation known as *weathering*. This is a process of disintegration due to the common meteorological agencies. Water in various states is the chief in efficiency amongst these, and, accordingly, the chief phenomena of weathering will come up for discussion in a later paragraph. But the air itself is accountable for a good deal of rock destruction. In the first place, the *changes of temperature* which are constantly occurring have a very important effect upon the rocks which are subjected to them, more especially in tropical countries, where the daily range of temperature between noon and midnight may be as much as 100°. It is a matter of common knowledge that most solid bodies expand when heated and contract when cooled. Thus, railway engineers never lay two rails absolutely touching one another at their ends, but leave room for expansion under the midday sun of summer, otherwise they would bulge out of truth. In the case of natural rocks, where no allowance of this kind has been made by the constructor, the rapid *expansion* and *contraction* which alternate with changes in atmospheric heat frequently cause them to split and throw off fragments. These fragments disintegrate in the same way, and, ultimately, large masses of rock are thus broken down into more or less fine dust, which is blown away by the wind. The effect of this atmospheric disintegration is chiefly seen in the arid plains of the great tropical continents, where there is practically no water present to resist or complicate the process.

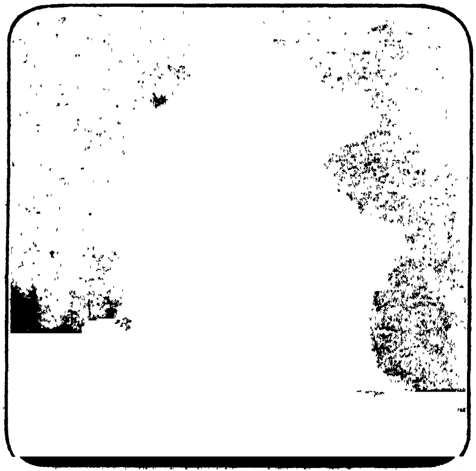
Eroding Action of Sand-laden Wind. There is another way in which wind acts powerfully to break down rocks. Where there is already present sand or fine detritus, which the wind can take up and carry along, we have to reckon with the abrading effects of this dust upon the rocks against which it is driven. The wind thus charged becomes, in fact, a kind of *sand-blast*, such as is used by glassworkers to etch names and figures on their wares. A powerful wind, driving gusts of sand before it, is capable of doing a wonderful amount of work in this way. It has been estimated that a sheet of plate-glass which once formed a window in an American lighthouse was so affected by a wind laden with sand in the course of 48 hours that it was ground completely opaque, and had to be removed. In the deserts of Libya or Wyoming rocks and monuments are found to have a characteristic polish or glaze, which is due to the constant sand-blast to which they have been exposed in every high wind. The deeply pitted marks on the face of the Egyptian Sphinx [**49**] are similarly due to the abrading effects of the sand-laden wind of the desert.

Atmospheric Erosion. Thus we see that the air alone is capable of doing much to change the face of the earth. It breaks down rocks into small particles of sand by rapid changes in temperature, aided at times by lightning. It transports the dust thus formed for great distances, and sometimes heaps it up into hills or vast drifts. And in the act of transporting the sand, it wears down and cuts away the rocks over which it passes.

The Work of Water. By far the most important of the natural agencies which modify the surface of the earth is that of water in its various forms. The surface of the land has been very largely moulded by the great circulatory system of water, which plays so large a part in our lives. The atmospheric water, in the form of *rain*, *hail*, and *snow*; the terrestrial water, in the form of *rivers*, *waterfalls*, *springs*, and *lakes*; and the marine water, which forms the *oceans*; besides the frozen water, which fills the Alpine valleys and covers the Arctic plains with vast *glaciers*—all play a great part in the moulding of the surface of the land. Each of these divisions will require separ[illegible] treatment.



51. TYPICAL WEATHERING OF ROCKS



50. HEMLOCK STONE, NOTTS, SHOWING EFFECT OF WEATHERING

Atmospheric Water. We shall [illegible]t consider atmospheric water. There a[illegible] Th[illegible]e states in which water is known to exis[illegible] the earth. It may be *solid*, like ice, [illegible] hail; *liquid*, like the ordinary form i[illegible] know it; or, again, *gaseous*, as water [illegible] or steam. It depends merely on temp[illegible]nd pressure which of these three fo[illegible]s. There is a vast circulatory system [illegible]s at work, under the influence of the su[illegible]y which water passes from the great reservoirs of the oceans into the form of water-vapour suspended in the atmosphere, falls then upon the surface of the land as rain or snow, and then, in the form of rivers or glaciers, makes its way back to the sea, thus completing the cycle. [See page **554**.] It is in the course of these processes that the geological work of altering the surface of the land is very largely done. This work is partly *chemical*, done by the solvent action of water on the various substances through or over which it passes, and partly *mechanical*, done by the movements of the water and the solid matter which it may carry in solution.

Rain. We shall begin by considering *rain*. This is absolutely pure water, having been distilled by the sun, when it first passes back into liquid form in the upper regions of the air. But as it falls through the air it absorbs a certain amount of impurities. Among the most important for our purpose is carbonic acid gas (CO_2). Rain also dissolves a small amount of oxygen in its passage through the atmosphere, and it frequently picks up other impurities, especially in the neighbourhood of manufacturing districts, such as nitric acid, sulphuric acid, and organic matter. When the rain falls upon the ground one of two things happens: either it is absorbed, if the surface be permeable, or it trickles along the surface in the direction of the most rapid slope. In the former case it becomes what is known as *underground water*; in the second case it feeds the incipient *rivers*. It is the rain which is absorbed into the rocks which is chiefly responsible for their chemical change, while the rain which flows off into rivers performs the greater part of the mechanical, or erosive action of water.

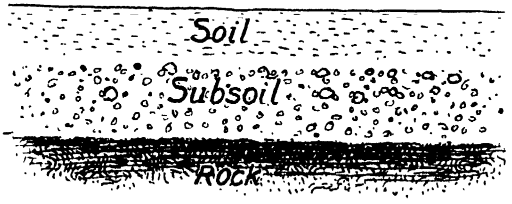
Weathering. The chemical action of rain is mainly responsible for the *weathering* of rocks. This usually signifies a disintegration of the surface due to a chemical decomposition. Some of the hardest rocks are most liable to weathering. Thus, granite frequently decomposes into clay, while the softer limestone keeps a hard surface. Water, by itself, is powerless to affect a large number of rocks, though a few—such as rock-salt—are distinctly soluble in it. But water containing oxygen and carbonic acid gas, as is the case with rain which has fallen a long way through the atmosphere, acts upon a very large number of rocks. Limestones, for instance, are rapidly dissolved by water which contains carbonic acid gas, and are thus gradually worn away, or pitted and drilled, by the action of rain. This is why the mortar of houses requires periodical renewing on the surface, or pointing, and why the inscription on a [illegible] monument generally has become illegible a[illegible] or 50 years. The wonderful caverns in [illegible]estone districts of Derbyshire and Ken[illegible] all been carved out by the solvent [illegible] of water containing carbonic acid gas.

Oxidation and Reduction. Rainwater generally [illegible]ains a small quantity of *oxygen* dissolved in [illegible] and this oxygen is able to unite with other elements and form oxides in a much more vigorous fashion than the free oxygen in the air. [See CHEMISTRY.] This process of *oxidation* is what is popularly known as rusting, and the red or yellow crust which is so commonly seen on rocks over which rain has trickled is its product. On the other hand, rain which contains organic matter acts as a *reducing* agent; it decomposes oxides and takes away part of their oxygen, owing to the affinity of that gas for carbon. This is the cause of the white spots or veins so common in red sandstone, where the colouring matter of ferric oxide has been reduced by the presence of some organic matter which is greedy for oxygen.

The great class of *silicates*, which form so large a part, as we have seen, of the rocks which compose the crust of the earth, are readily decomposed by rainwater containing carbonic acid gas. They break down into clay of one kind or another, and in this way granites which have long been exposed to the action of rain are found to have disintegrated or crumbled away for a considerable depth from the surface. There are countless varieties of weathering or meteoric change in rocks, depending on their chemical composition and the nature of the impurities in the water which has run over them.

Rock Sculpture. The weathering of rocks not only alters their composition and hardness, but also has very marked effects upon the general appearance of their masses. No rock is absolutely *homogeneous*; some parts of it are harder than others, some are more readily dissolved or broken down than others. Consequently, after the process of weathering has gone on for a considerable time, the rock is found to have been carved into quite a different shape from that it originally possessed. The softer parts have been eaten away, and the harder ones are left standing up in pinnacles or projecting as boulders. Some rocks, like basalt, weather in a series of crusts like those of an onion, until after a long while the whole mass looks like an accumulation of cannon balls. Granite often weathers into large slabs, which produces the effect of a wall of masonry. In the Cevennes and the Hartz Mountains, the weathering of dolomite and limestone produces masses of stone which look like ruined castles. The tors of Dartmoor are a familiar example of the forms produced by the weathering of granite. Characteristic examples of the result of rock weathering are shown in **50** and **51**.

Formation of Soil. To us the great importance of the weathering of rocks consists in the fact that it is from their decomposed materials that soil, or earth, is mostly formed. The *soil* originally is simply the weathered, decomposed, and loosened surfaces of the rock over which it lies. There is usually an intermediate stage known as *subsoil* [**52**], which consists of larger broken or loosened fragments of the rock, and which passes upwards into the soil which supports vegetation, and downward into the solid rock. Its nature varies according to the rock from which it has been derived.



52. DIAGRAM SHOWING FORM OF SURFACE EARTH

For a full consideration of the nature of various soils the reader must consult the course on AGRICULTURE. It is enough to say here that all soils practically consist of *sand* or *clay*, or a mixture of these two main substances in various proportions. A fairly equal mixture of sand and clay is known as *loam*, and affords the best soil for agricultural purposes. It is, of course, the

53. ON THE ROAD TO GRAND CURRAL, MADEIRA, SHOWING THE ACTION OF RAIN UPON THE HILLSIDE

J. Valentine

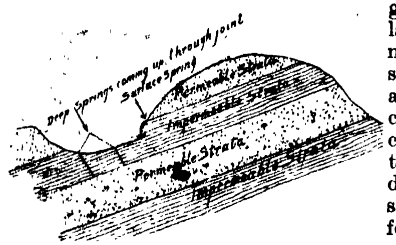
addition of organic substances to this soil which chiefly helps to make it fertile. But the actual existence of soil over the whole habitable surface of the earth is due to the weathering, or decomposition, of the primitive rocks by the agencies of air, water, and other meteorological forces.

Erosion by Rain. In addition to the chemical action of rain, it also has a mechanical, or *erosive*, action upon the earth. We can readily see of what nature this action is if we go back to the habits of childhood and make a mud pie. Let us go into the garden and heap up a roughly conical mound a couple of feet or so in height; then take a watering-can or hose and sprinkle it with water. Under the miniature rain shower, which runs down all sides of our mound in little streams, we shall see that the looser and more soluble portions of earth are washed away and the sides of the mound are furrowed in all directions by miniature river valleys and stream lines, between which the stones and harder portions of the earth remain standing up. If the rain goes on long enough, one after another of these stones will be undermined and roll down the slope, until ultimately, if we go on watering long enough, the whole conical hill will be washed down into a low mound, of which the greater part is spread over the surrounding earth.

Fantastic Effects of Rain. This simple experiment is a very good object lesson in *the mechanical work of rain.* Wherever it falls faster than it can sink into the ground, it runs down the nearest slope and carries with it a certain amount of soil, selecting, of course, the softest and least resisting parts, and leaving the harder proje[illegible] from the ground. Thus, the hillsid[illegible] the tendency of rain is steadily [illegible] down to the general level of the earth, is usually scoured into more or less irregular forms. If the rainfall is considerable, and the inequalities in the texture of the ground are great, we shall find well-marked torrent-beds which are like stony, sunken paths in dry weather, and become gushing streams in the wet season. This is a very common feature on our British hills. Sometimes, as in the valley of the Tyrol, the stony clay is cut by the rain into actual pillars, which are left standing up because each of them happens to be protected by a huge boulder, which diverts the rain from the ground immediately below it. In other parts, where the soil is all pretty much of the same texture, the whole of a vast stratum may be washed away, leaving only a few relics to tell the geologist that it once existed. It is these inequalities in the erosive action of rain, depending upon the heterogeneity of the soil on which it falls, that have carved our hillsides and mountain slopes into so many fantastic, wild and beautiful forms [53], besides giving us the greater portion of the soil which smiles with harvest.

Hail, Snow, and Frost. The other forms of atmospheric water—*hail* and *snow*, *dew* and *hoarfrost*—call for little notice from the geologist. The effects of melting snow are practically the same as those of rain, except that when a large deposit of snow melts rapidly it, of course, gives birth to more considerable torrents than an ordinary rainfall can produce. The work of snow-fed glaciers, which is one of the most important factors in geological history, will be separately considered in a later chapter.

Underground Water. We have seen that rain falling on the ground either sinks into the surface or runs off. Which of these events happens depends on the relative permeability of the surface of the ground and the heaviness of the rainfall. If the rain fall on a surface like granite or a street pavement, it all runs off and joins a river or a gutter. If it fall on a surface as permeable as loose sand or ordinary grass-land, it nearly all soaks in; and, of course, every intermediate stage is found to exist in Nature.



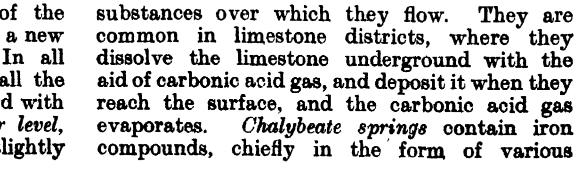
54 DIAGRAM SHOWING WATER SPRINGS

We shall first consider the rain which soaks into the earth and forms *underground water*.

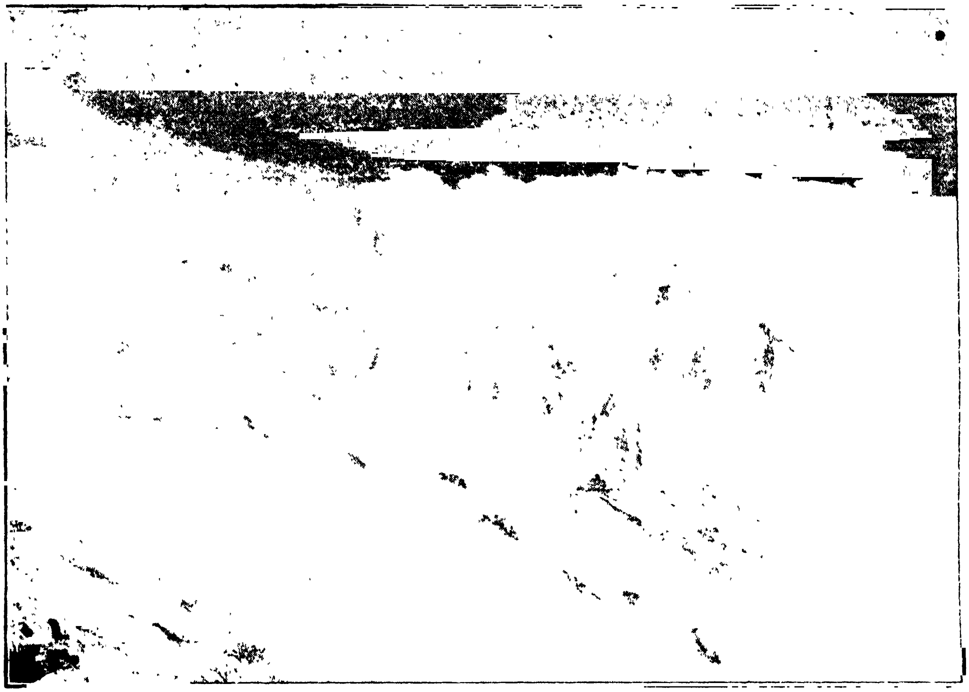
Springs. The law of gravity causes rain to go on descending by its own weight as far as it can. Sooner or later, as a rule, it will reach the limit of permeable strata and bring up against the underlying stratum of impermeable rock. If this bed lie on a slope, as is usually the case, the water runs down this slope, forming, so to speak, an underground river, though it must not be supposed that it is usually so well defined as a surface river; it is rather a great mass of saturated sand or gravel, like a sponge full of water. If this underground reservoir, as we may call it, find an opening to the surface of the earth at a lower level than that of its own surface, the water will there emerge as a *spring* [54], which will flow steadily so long as the level of the water in the underground reservoir does not fall below the point at which the spring emerges. If, in a season of drought, no rain fall to keep the underground reservoir full, and the water ultimately fall below the level of the spring, the water will cease to flow, until a new rainfall again fills up the reservoir. In all countries where there is a regular rainfall the permeable rocks are found to be saturated with water below a line known as the *water level*, which is fairly constant, but rises or falls slightly with a wet or dry season. A *well* is simply a hole dug into the earth below this line, so that the water trickles down into it and keeps it full up to the water level. An *artesian well* [55] is a well sunk through an impervious surface bed, such as clay, down to a porous stratum which lies beneath it. It often happens that this porous stratum slopes down from the surface of the earth at a considerable distance away, and its *catchment area* may be higher than the point at which the well is sunk. If this be the case, when the well reaches the porous stratum the water will gush up to the surface, and even rise in a fountain under this hydrostatic pressure, just as a garden hose will throw a jet considerably above the level of its tap.

Hot Springs from the Earth's Kitchen Boiler. Many springs emit hot water, which in volcanic districts may even be boiling. They are found in our own country, which is far from any volcanic centre, as at Bath, with a temperature as high as 120° F. These have clearly risen from a great depth, where the water has been heated by its proximity to the earth's kitchen boiler. They are natural artesian wells [55], in which the flow of the water is due to the fact that its channel communicates with some catchment area at a higher level than where the spring comes to the surface—that of Bath is possibly on the Cotswold Hills. The common distinction between *deep-seated* and *surface* springs is merely one of degree, depending on whether the water emerges by a simple descent through the subterranean strata—*e.g.*, from the top of a hill to the valley—or is forced up by hydrostatic pressure through a natural syphon. Nor is the distinction between *constant* and *intermittent* springs of any great importance, except to those who get their water from them.

Mineral Springs. All spring water, however clear and pure it may appear, contains various impurities in solution. These consist of dissolved gases and minerals, derived from the rocks through which it has passed. When the water has descended low enough to be considerably heated, its solvent powers are, of course, increased. *Mineral springs* are so called when they contain a marked amount of minerals in solution. Thus we have *petrifying springs*, the waters of which contain so much calcium carbonate as to deposit it in a white crust on the substances over which they flow. They are common in limestone districts, where they dissolve the limestone underground with the aid of carbonic acid gas, and deposit it when they reach the surface, and the carbonic acid gas evaporates. *Chalybeate springs* contain iron compounds, chiefly in the form of various



55. DIAGRAM SHOWING THE CAUSES OF ARTESIAN WELLS



56. LANDSLIP NEAR LYME REGIS

Valentine

sulphates. *Brine springs* are impregnated with salt, derived from beds of rock salt in the earth beneath. There are various kinds of *medicinal springs*, which may be alkaline, as at Vichy; bitter, as at Kissingen; salt, as at Wiesbaden; limy, as at Bath; or sulphurous, like the well-known "rotten-egg" water of Harrogate. These are often warm, or *thermal*, springs.

Underground Caverns. The chemical action of underground water consists mainly in dissolving the various substances which are then brought up to the surface by springs. It is obvious that if this considerable amount of material is brought up from beneath the earth's surface—some limestone springs have built up actual hills—there must be a vacant space left where it was removed. Thus we find that considerable subterranean *caverns* and *tunnels* are formed by the solvent action of underground water. This is particularly noticeable in limestone districts, where vast systems of caves have been hollowed out during the lapse of ages. The caverns of the Peak in Derbyshire and the Mammoth Cave in Kentucky are famous instances. Not infrequently the roofs of these underground caverns collapse when they come too near the surface, and *landslips*, or *subsidences* of the ground, must take place without warning. The meres of Cheshire chiefly occupy places where the land has subsided in consequence of the washing out of the underlying beds of rock salt. Some earthquakes are probably due to the shock caused by the falling in of the roofs of the deep caverns.

Landslips. Underground water has not only a chemical, but also a mechanical action. It acts as an *erosive*, no less than as a *solvent*. This is especially the case where water runs through a porous stratum sloping under a mountain or hill. The material of this stratum is gradually washed away, until it becomes unable to support the overlying strata. The ultimate consequence is a *landslip*. A great part of the English coast is marked by the remains of such landslips, which form a picturesque feature, known as the *undercliff* [56]. A large part of the town of Sandgate was destroyed by such a landslip in 1893. Landslips in mountainous and rainy countries are often far more destructive than any that we experience. The traveller by the St. Gothard Railway still notices the huge scar on the side of the Rossberg which marks the place where the whole side of that mountain slipped into the valley after the rainy season of 1806, burying four villages with their inhabitants. The percolating water in such cases not only weakens the strata through which it flows, but also acts as a lubricant, and thus a great mass of rock begins to slide when its weight finally overcomes the power of cohesion. Destructive landslips are not uncommon in India, and about 150 have been recorded in Switzerland. In Ireland we occasionally hear of a similar phenomenon, known as a *bog-slide*, when the whole surface of a bog, or peat-moss, becomes so saturated with water that it breaks from its moorings and flows bodily downhill.

Continued

PIANOFORTE
continued from
page 1418

POSITION OF THE HANDS

Rotary Adjustment. Bent and Flat Finger Attitudes. Toneless Exercise. Wrist Movements. Scale Playing

By M. KENNEDY-FRASER

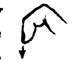
WE have dealt chiefly with the *condition* of fingers and hand, and little with the secondary consideration of position; but an interesting question of position arises out of this rotary condition. When the little finger bears up against the forearm rotation its knuckle is brought well up to the level of the hand, or may even be higher than that of the index finger. The position of the back of the hand is consequently level, and even forms a slight slope from the fifth-finger knuckle downwards towards the thumb. The opposite state of affairs is a common fault with beginners; they are apt to let the back of the hand slope very much down towards the outside. But let us beware of trusting too much to appearances; right positions are to be secured, and it is not enough that the hand should *look* like that of a successful player. We may have the appearance of effective "rotary adjustment" without the reality.

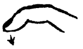
The use of the rotary adjustment does not apply merely to the fifth-finger side of the hand; it is employed constantly to equalise (or non-equalise, when necessary) any fingers to make notes—melodies, for instance—stand out at either end of the hand. As this rotary adjustment may help, so it may hinder, when applied in the wrong direction. Be careful not to allow any rotary action of the forearm to keep energy *away from* the side of the hand where it is required.

Finger Lifting. We have seen that the finger must make careful contact with the key, or rest on it, before moving it, but it need not be cramped by being glued to the key, as it were, all the time. It may be swung up a little, provided always that when it renews contact with the key it judges its resistance before and during key depression. This judging can be done so quickly that it seems like a continuous movement.

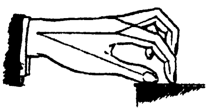
The key moves such a small distance (only ¼ in.) that the fingers are apt to get cramped by such slight movement; hence, it is customary to advise—most teachers, indeed, specially insist upon—an upward movement of the fingers, when there is time for it, before taking hold of the key to move it. Such movement is not essential to tone production, but is healthy for the muscles. It makes for freedom of action, and enables us better to "think the fingers," provided that there is no stiffness in the upward movement or following down movement, and provided that we do not allow our attention to be distracted from the following finger descent. All such movements *towards* the keys, indeed, whether of finger, hand, or arm, should be rather passive than active.

Bent and Flat Finger Attitudes. For brilliant, clean-cut tone, if we play the keys from a little distance, the fingers should be bent, as shown in this diagram. For sympathetic, clinging tone, the fingers in moving towards the key should be left rather straighter, as in the lower of these two diagrams.





These two contrasted "finger attitudes" are not only both legitimate, but are essential to truly artistic, varied, contrasted technique, and we must practise both forms. In using the "bent finger," the nail-joint moves up and down in a straight line vertically with the keys, thus: and brings the very tip of the finger (close to the nail) in contact with the key. In "flat finger" the nail-joint moves obliquely to the key, and brings the soft cushion (opposite to the nail) into key-contact. The chief difference to the *eye* is that, when the finger is well raised as a preliminary, it starts very much curved in the "bent," and fully opened out in the "flat," attitude. The "bent" requires the knuckle sufficiently high to take the thrust, the "flat" admits a very low or very high wrist.



Arm-weight Tendencies. The bent-finger attitude may be called the "thrusting" attitude, the flat-finger attitude the "clinging" one. With the bent finger the weight of the arm tends slightly *forward;* this should be only an inward muscular tendency, there is no outward visible movement, and in brilliant finger work we should never forget this "forward tending" arm—it makes one's playing feel as easy as running downhill. With the flat finger, on the contrary, "the arm tends to fall backward," but we must be careful not to *pull* the elbow backward instead.

Bent and Flat Finger Touches. The "forward" bent-finger playing favours sudden key-movement, which induces brilliant, short tone; the "clinging" flat-finger attitude, with its backward tending arm, favours gradual key-movement, which induces sympathetic singing tone.

"The anticipated fall of the upper arm causes one to use the finger in the clinging or 'grabbing' way, while the consciousness of the forward sustained elbow causes one to use the fingers in a kind of stamping or thrusting action." [Matthay] For brilliant work, then, see to it that we sustain the weight of the elbow forward, and that for beautiful singing tone we allow it rather to tend to lapse backward.

It is this flat-finger clinging attitude that we must use in playing a great deal of Chopin's music. Chopin himself often used this form of technique, and consequently pianists who may have been drilled entirely in the bent-finger school do not succeed in playing the master unless they either forget the tyranny of their method or ignore it.

Faulty Technique. We must consider all these things even at this early stage, although we may not be able to realise them till much later in our study. If we are not getting along easily with quick, brilliant passages, for example, it is either because we are key-bed squeezing, or because we are opposing the acting muscles by the sympathetic activity of the opposite set of muscles, which ought to remain passive, thus setting up obstacles to successful and easy playing *within our own hand and arm ;* or. again, because we are trying to play a brilliant passage with a backward hanging arm, instead of keeping all the weight well forward, which would cause the fingers to feel as though they were running downhill.

On the other hand, when trying to play a long-drawn-out melody we shall fail unless we let the whole arm relax before and while we move the key, and let the " clinging " attitude (with flatter finger) feel as though, "in climbing a stair, the hand, gently resting on the banister, helped to pull us upstairs."

" Finger-condition Test." We have had a toneless exercise at the keyboard for daily testing the relaxed condition of the "up" muscles of the hand; here is one for testing the same with regard to the fingers. Rest on the keys as before, without depressing them, and, with a forward movement of forearm, push the hand gently towards the black keys (the wrist here moves on one plane, and does not, as in the former example, rise and fall), rolling the fingers up and, as it were, passing them by. This forms the second part of the first of Matthay's three chief muscular tests.

If the " up " muscles of the fingers are relaxed, the tips will remain in their places, while all the joints will give way, and allow the fingers to be rolled up into an exaggerated bend on the keys, as though they were about to take the shape of a closed fist. The gentle resting weight must be felt continuously on the keys. If the " up " muscles were not relaxed, the fingers would " lock " the knuckles of their little joints, as the hand can lock its big knuckle, which we call the wrist. In such a locked condition the finger-tips would slide to and fro on the slippery ivories, and be in a totally unfit condition for successful playing. We must be constantly testing them for this. The student should write out these " daily tests " and playing maxims on a card, and keep them before him during practice.

In both of these silent keyboard tests, the finger-tips retain their places on the keys. In the first, the wrist rises and falls ; in the second, it moves to and fro towards the ebonies and back again in the one plane.

There are two other " tests " which have to be considered—the test against down-arm force and the tone-aiming test ; one *to ensure the arm being used only as a weight reservoir,* so to speak, and the other *for the practice of precise aiming* —aiming of the tone-making spurt, the added impetus that is used between two " restings."

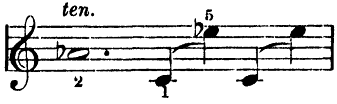
Arm Force Elimination Test. For the first, at the end of a short run or arpeggio we are to let the arm rebound from the keys. If the last note be played *forte e marcato,* the arm will seem to be " kicked off "; if, on the other hand, the final note be soft, the arm will appear to be " floated off." In either case the movement must be of the nature of a rebound, absolutely unwilled and *staccatissimo;* it must not, in its initial stage, be a willed action, "it must *seem* as if the key, in its rebound, impelled the arm upwards."

The next test is an " aiming " exercise. We have seen that finger and hand down muscles are used to bear up against relaxed and loosely left weight of the arm in the third species of touch ; and as this weight is to be used only during the short spurts of hammer-driving, and not during the longer or shorter terms of damper-controlling, we must learn so to aim this arm-weight lapse that it shall take place neither too soon nor too late, nor remain in operation too long.

Aiming Test. The " aiming test," then, may take this form. Rest on the keys, say, on an easy chord ; see-saw them gently down and up several times (tonelessly) ; after that, let them move down to tone, and *let them rebound,* the fingers never losing their hold of the keys, and the wrist, which is relaxed at the moment of making the tone, then being dropped below keyboard level.

If the student wishes for a detailed description of all these " muscular tests," which are taken from Matthay's " Act of Touch," reference must be made to the book itself, or to the condensed edition, " First Principles of Pianoforte Playing," or, better still, to his "Relaxation Studies."

We now come to the question of " getting about " over the keyboard—a difficult one, as we have but ten fingers for 88 keys. We have tried only the five-finger position, five fingers on five contiguous ivories. Now let us try to sound widely spaced notes, thus :



Lateral Wrist Movement. To reach them, we must not try to depend upon a stretching of the fingers and hand ; we must use also a side to side movement of the wrist to bring each finger in succession over its keys. This lateral movement must be as free and unopposed as the vertical wrist movement.

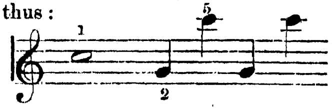
Resting gently with forefinger on A♭, glide the wrist end of hand and forearm gently to the left. Place the thumb on C, then, after sounding the note, move back again towards the right, continuing the movement till we can easily place the little finger on E♭.

All arpeggio chords must be played thus, and to attempt to do so by merely *stretching* the fingers is apt, in such cases, to defeat its own object. The hand and arm, with supple lateral wrist movement, must place the fingers on their respective keys.

Preparing a Note. We must remember here, and always, Czerny's advice in his "Letters to a Young Lady," written 100 years ago: "Never attempt to play a note till the finger is over its key." This is called "preparing" a note. But the vital point in "preparation" is not the *position* of finger and hand over the key, but rather the *condition*. If the principle of resting is properly carried out, this preparation of the next note will take place almost automatically. "Each of the keys forming a passage," says Matthay, "must be conceived not as a separate unit, but each key's position must be conceived and found at a *particular distance* from each *preceding key or keys*." The finger being over and even *on* each key, energy must be applied to it *vertically*.

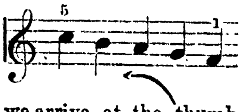
Wrist Movements. We have now been introduced to the three kinds of wrist movement and condition—*viz.*, (1) vertical (up and down) freedom and movement of the joint between hand and forearm; (2) rotary freedom of the same, enabling us to turn hand palm upwards, or vice versâ, and to adjust the rotary weight; and, lastly, this (3) *lateral* freedom—unopposed movement from side to side. There are *no stiff* wrists in normal arms—the stiffness is entirely of our own making. If the wrists prove stiff in any direction, we are using two opposite sets of muscles at once, instead of relaxing one set while the other is at work. "If we always insist on feeling *ready* and *vertical* over each note before attempting its production, we shall fulfil the three conditions of freedom of the wrist—laterally, rotarily, and vertically. While trying for it, we must not be too anxious—mental anxiety often induces muscular rigidity—but we must be attentive. We must watch our sensations, and try to remember and easily recall them when wanted.

The lateral movement can take another form. Instead of pivoting the finger-tip end of hand, and moving the wrist end from side to side, we must also be able to let the wrist end remain motionless while moving the finger-tip end from side to side, with the thumb as a pivot, thus:

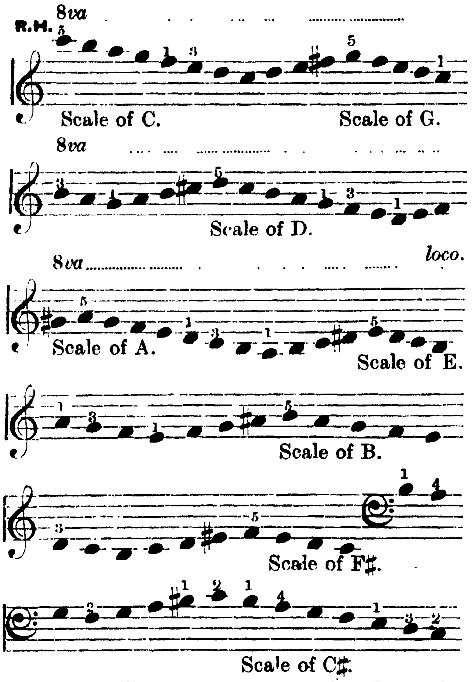


The study of these two forms of lateral movement brings us naturally to arpeggio and scale playing.

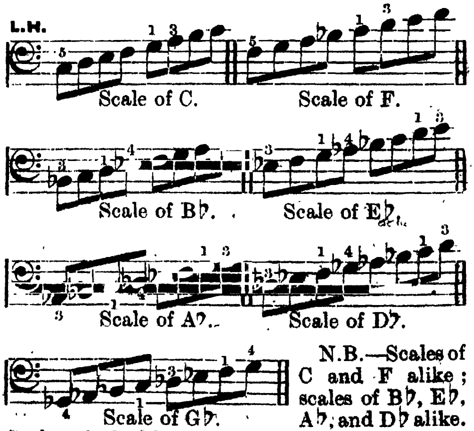
Scale Playing. Let us take our five-finger position thus: but let the hand lie obliquely over the keys, turned slightly in the direction of the arrow, and when we arrive at the thumb pass the hand laterally over it, till the middle finger lies on E. Then, releasing the thumb from its under-hand pivoting, pass it along the *keys* leftward, preparing thus the two remaining notes, D and C. In scale passages the hand always lies thus slightly obliquely to the keys. "The scale, owing to the required passage of the thumb sideways, demands a slightly *outwardly* turned wrist, or *inwardly* pointing hand and fingers, as the normal position." [Matthay]



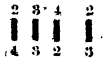
Study the scale at first in the manner given here, each hand separately



N.B.—Each sharp as it is introduced is to be in force till the end of the exercise.



N.B.—Scales of C and F alike; scales of B♭, E♭, A♭, and D♭ alike. Scale of G like all five-black-note scales:



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BUILDING UP THE FIGURE

Casting the Figure. Modelling the Head. The Measurements. The Eyes and Hair. Securing Good Models. The Clay. Removing the Piece-mould

By COURTENAY POLLOCK and P. G. KONODY

Casting the Figure. The methods of mixing and using the plaster, the use of the coloured coating, and the washing and oiling have been explained previously. The few tools required in addition to those used in relief casting will be mentioned as occasion arises.

If the arms are not attached below the shoulders to the figure, or if the hands only touch the figure, it will be necessary to remove them at the point of the insertion of the deltoid. To do this neatly, cut through the clay with a piece of fine wire, and with a fine meat-saw cut gently through the tubing. Lay the arms upon some soft material which will not scratch the surface, and proceed to make the mould for them. Roll out some strips of clay about ¼ in. thick and 1 in. wide. These must be cut straight with a knife, for they are to be placed clean and square upon the arms, to form the division for the making of the two halves of the mould. Begin at the outside of the wrist at the styloid process of the ulna, and build the division up that side of the arm across the cut end and down the other side, and continue it round the tips of the fingers, filling in between the fingers if they are separated. If the hand is closed, take the division round the knuckles, and join it to the division at the other side of the wrist. The arm will now have a projecting flange dividing the back from the front.

Over the back portion place some tissue paper, slightly damped to prevent it from scratching the surface of the clay. This will protect it from grit and splashes of plaster during the making of the mould for the front.

Make the mould for the front half as in relief work, but do not shake or move the arm while putting the plaster on. To avoid bubbles, throw the plaster into the crevices with the fingers, blowing it into the interstices where necessary. Keep the coloured layer of plaster thin, but not transparent.

The Keying of the Mould. Remove the tissue-paper at the back and the clay divisions carefully and cleanly. In two or three places of the mould thus exposed carve a shallow hollow by twisting a half-round end of a broad, flat knife upon the surface. When the second half of the mould is laid on it will form small knobs, which will fit into these cavities, and provide a key, to ensure the halves of the mould fitting accurately together. Oil the edge of the front mould after carefully removing every particle of the clay division, or loose plaster; then cover the remaining half of the arm exposed in the same way as the first. Cut the mould straight at the seam, so that the joint can be seen. Though at this point the arms may be left in their moulds while attention is given to the figure, it will be well to show at once how to complete the arm casting.

Completing the Arm Casting. Dip the arms into cold water for a second or two, and with a broad, thin knife, or the edge of a chisel, ease the halves of the mould carefully and very gently apart. Take out the clay, and wash thoroughly, using plenty of soft soap. Close the halves together, and at the shoulder end cut a hole through which to fill the mould. Wash out the pieces of plaster, and, after a thorough soaping, close them again, binding them securely with cord. The knobs of the back half fitting into the hollows of the other will prevent slipping. Have two pieces of very thick galvanised wire, about 4 in. long, double them, and have them ready to fix into the end of the arms, to strengthen the joint at the shoulder. Mix the plaster, and pour it into the mould, shaking and turning it about, and pouring it off and refilling in order to ensure the plaster reaching and quite filling the extremities. Fill the mould up solid, and, while it is setting, insert at the open end the piece of wire, pushing it in till it is half buried.

Dividing the Figure. Let us now return to the figure. Take some strips of clay similar to those used for the arms, and with these divide the figure from the bottom of the plinth at the side and in a line with the outer ankle of the standing leg, across the plinth to the ankle, up the outside of the leg and trunk, over the shoulders and head, and down the other side and across the plinth to the other ankle. Another division must be made across the back from one side of the main division to the other at the level of, and cutting through, the insertion of the iron support—*i.e.*, about the middle of the gluteus muscles. The space between the legs must be filled in by a thin wall. Be careful to keep this clay smooth and neat at the edges. It will be seen then that, when the mould of the back is made, the upper and lower halves will come away without the iron support interfering.

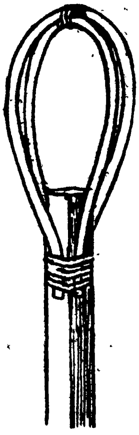
Removing the Piece-mould. Work in exactly the same way as with the arms, covering the front of the figure with one mass of plaster mould. Then remove the tissue-paper and the clay divisions on the lower half of the back, and the divisions between the legs. Do not remove the cross division of the back before the lower half of the mould has been made. Then remove all the remaining divisions, and, having well oiled the exposed edges of the mould, put on the plaster for the upper half of the back, and with a strong knife trim at the joints so that the seams may be seen distinctly. Now leave it for about an hour, during which time the arms may be finished. While chipping away the mould, they should rest on some soft material, so that there is plenty of "give," or the cast may be easily broken.

The Lather. In removing the piece-mould from the figure a little water is needed. Insert the blade of a knife into the seam at the head; use the knife as a lever, very gently working it forwards and backwards until there is a little movement between the pieces of the mould. Then pour into the seam a small quantity of water to relax the hold of the clay on the plaster. The carefully-removed pieces of mould should be washed and soaped with a very good lather. Oil is not the best thing to use, as it often discolours the cast. But it is good to use plenty of soft soap, and lather well with a large brush until the surface is hard and shiny. In putting the mould on the clay figure, the notches should be made on the edge of the first half, as in the case of the moulds for the arms.

Put the mould together, and bind tightly with cord; fill in with plaster, pouring it through both openings at the feet. Plenty of plaster should be kept ready mixed, and this should not be very thick. Plaster swells when setting, and, if used too thick, may crack the mould. It should also be remembered that a very thick mixture may set before the mould is properly filled.

Chipping. In chipping it is advisable to begin at the head and shoulders and remove the white covering. When this is quite cleared, remove the coloured coating from the top downwards. Thus the cast will be kept clean, and no falling plaster can scratch the surface.

The figure need not always be cast quite solidly. With a little practice the student will be able to judge the thickness and uniformity of the cast as he is making it. In repairing bruises and scratches, the injured parts should be well wetted before being filled in. To fix the arms, make a hole to receive the wire strengthening, thoroughly wet both the end of the arm and the shoulder, mix some plaster and throw it into the hole. After scratching away some of the end of the arm, so that it is slightly concave, press it into position and hold it there for a few minutes until it is well set. No plaster must be allowed to get between the *surface* of the end of the arm and the surface of the shoulder, else it is not possible to secure a perfect joint.



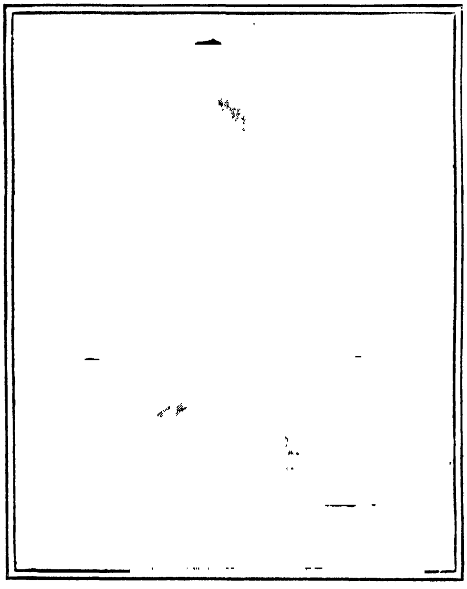
28. ARMATURE FOR HEAD

Modelling the Head. The armature for a head from life is not very difficult to make. A board 18 in. square is required. Into this an upright piece of wood, 2 in. square and 9 in. high, should be fixed very securely. Two pieces of "compo" tubing are fastened so that they make two loops which shall continue up the centre of the head, one inside the other, and give the clay plenty of support [28]. These loops should be from 10 to 12 in. long. This flexible armature will permit of bending the head to give it any necessary pose when the clay has been put on. It is sometimes necessary to make use of butterflies to strengthen the support of the clay. These should be fastened to the top of the tubing, and allowed to fall to about the middle of the head—one in front and the other at the back. When the armature is finished, place it on the turntable and cover the whole of the framework with clay. Begin at the neck and put on about 2 in. of clay front and back, and the same at the sides. This will ensure the supporting column being in the middle of the neck. Continue this column of clay upwards and downwards. Then, having covered the framework of the head, you will have a slightly egg-shaped mass at the top of the clay column.

Working from the Profile. Now turn to the profile, and having fixed the point of the pit of the neck at the suprasternal notch, make the profile of the sternum. Then from the front fix the angle of the clavicles, and continue them to the shoulders, filling in and defining the planes of the pectoral muscles. From the profile fix the angle made by a line from the suprasternal notch to the seventh cervical vertebra. To find this vertebra is not difficult, as it is the most prominent point at the back of the neck, and cannot be very well mistaken. Having fixed this angle by sticking a tool or match into the back, carefully move the match horizontally till it is quite in the centre, and take careful measurement from this point on the model to the suprasternal notch. Compare this measurement on your clay and pull out the match to the distance required, securing it in position with lumps of clay. Then roll some large lumps between your hands, and put on the upper part of the trapezius in muscle, filling the back as far as the shoulders.

The Features. Having prepared your ground-work, take the following measurements upon the model, and fix them in order upon your clay work. Matches are most convenient to mark the points, and should be pushed into the clay until the extreme end represents the actual measurements.

With a pair of callipers measure from ear to ear at the notch between the tragus and antitragus. As the starting points from which you will measure your head, their position should be determined with great care. In marking them note the relative positions of the suprasternal notch, the seventh cervical vertebra, and the points just measured. This should, of course, be done from the profile. Calculation should be made as to how far above the sternum they come, and how far back they will be from the point of the chin. From the front it should be observed that the two points are perfectly horizontal. Again turn to the side view, and, holding a straight-edge, ascertain the position of the tip of the nose in relation to the point of the ear. Observe this from both sides, and mark what you judge to be the projection of the nose by putting on a piece of clay. Now measure this point from the ears. It is necessary to measure from both sides, as the position of the nose is not always equidistant from both ears. Build up the nose; do not put on too much clay, but just enough to make your measurements secure. With the callipers, measure from the notches of the ears to the middle of the chin at the extreme point of projection. Put on some clay, and with the notch of the ear as centre make an arc perpendicularly on the clay you have put on for the chin. The measurements from both sides must be exact.



Alinari

29. HEAD OF A YOUNG MAN
By Donatello

Locating the Point of Measurement. It will aid accuracy to place a small spot on the chin of the model, in order to locate the point of measurement. If your two measurements do not meet on the clay, there is probably too much clay on the chin. On the other hand, if they cross each other, there is probably not enough. When the two measurements fall into the same line on the chin, measure from the tip of the nose to the centre of the chin, and push in the match where this last measurement cuts the upright line marked upon the chin.

From the notch of the ear measure to the roots of the hair at the middle of the forehead. If the model has no hair on the forehead, measure from the line of the brows backwards till you reach the hair. The line of the brows should be calculated from the point of the chin, an arc being described with the chin as centre. Mark these measurements on a sheet of paper, so that in rectifying mistakes it will not be necessary to trouble the model by repeatedly measuring from him.

The next step is the laying in of the bone-forms. The use of a skull will assist the student in tracing these formations. The clay should be rolled into flat lumps before being put into position, and the student must refrain from smearing these over. If it is necessary to reduce the projection in any place, it should not be done by pressure, but by removing the clay. For increasing the hollow of the eye, the clay should be scraped or cut away. If the finger or tool is pushed into the clay the surrounding form will be thrown out of drawing.

Modelling the Bone-form. It is essential to devote the greatest possible care to the modelling of the bone-form, for upon this depends the character of the head. Draw the profile of the model from the chin over to the nape of the neck. If your points are accurately measured, there will be no danger in drawing this outline in full; but do not put on more than sufficient clay to give the outline of the profile. Put on the sterno-cleido mastoid muscles at the sides of the neck from the sternum to the mastoid processes at the back of the ears, and with a lump of clay indicate the position of the thyroid body. Put in the trapezius muscle, and mark with care the arch of the clavicles, looking up at them from below. Though it is safe to keep the muscles a little under size, the bones should from the first have their proper projection.

Lay in the jaws, noting the angle they make from the side and the arch they form when looked at from below. Indicate the shape of the brows and orbits. With great attention model the forehead and the cheekbones. Having put in the mass of the teeth, lay over them the forms of the lips and put in the nostrils. The mouth should be decided first by finding the corners and marking them, having regard to their relation to the wings of the nose. Indicate the ball of the eye with a round piece of clay, looking at it from the sides to make sure of the right projection beyond the outer border of the eye socket.

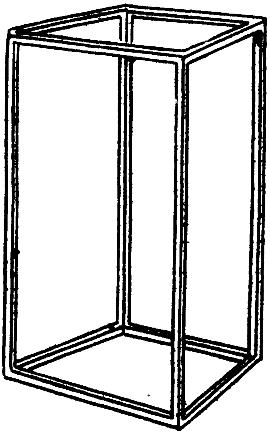
The Eyes. The student should now draw from the profile, from the front, and from the back, then the three-quarter views, drawing as he would with a pencil and paper, very carefully. The required action should be given to the head at this stage. The armature of the neck, being of "compo" tubing, is easily bent. Having done this, put on the eyelids top and bottom with small pieces of clay rolled between the fingers. Remember that the outer corners of the eye are higher than the inner.

Now cut out the pupils, leaving a small piece of clay in the pupil under the upper lid to catch the light, and so give the reflected spot of light seen in nature. The exact size and position of this spot depends upon, and should be determined by, the characteristics of the individual eye. If the eyes in nature are very dark, the best effect may be obtained by reducing the size of the piece of clay which catches the light. If the eyes are somewhat lustreless, the projection of this piece may be reduced so that the eye is reduced in brilliancy. Should the eyes be light, it is advisable not only to reduce the *depth* of the hole representing the pupil, but sometimes to make the angles at the sides of this hole less abrupt, and so obtain more light.

The Hair. The hair is always a difficult feature to imitate. It is hardly necessary to mention that in making a portrait it is not always advisable for the sitter to brush his hair. It depends entirely upon the manner in which he usually wears it. If he has rather long and crisp hair, which gives the general idea of ruggedness, it would be perfectly absurd to have it brushed down like smooth and fine hair.

Light and dark hair must, of course, be differentiated. To represent dark hair it is necessary to obtain as much shadow as will best give the effect. This may be done by cutting deep, crisp lines, so that the masses above shelve over and cast shadows. Light hair, if smooth, will require little or no heavy shadows; if rough and shaggy, the effect can be obtained by big masses and lines not cut very deeply. To what extent the hairs should be suggested is in a great measure a matter of "style." It depends on what the sculptor finds the most satisfactory way of rendering that particular example of hair.

The Ear. A great deal of attention should be paid to the ear. This feature varies in shape perhaps more than any other, and should therefore be properly considered. Notice the angle of its posterior border; mark how this border of the helix stands away from the skull, note from behind the shape of the concha and observe its depth. Again, much care should be given to realise the way in which the ear grows from the head. See how the tragus rises from the jaw. If regarded from the back, it forms part of the *round* border of the auditory meatus. It is then not flat, but convex. See also how the helix grows, not directly from the lower part of the temple, but from the cavity of the concha. And notice at the back the depth of the jaw and the way it is bordered by the sterno-cleido-mastoid muscle, and its insertion a little higher at the mastoid process. Knowledge of anatomy is of infinite importance. Without knowledge of its construction, the human form cannot possibly be correctly rendered.



30. FRAME FOR COVER

Models. Some difficulty may be experienced in securing good models. Perhaps the easiest and quickest way to get them is by advertisement. Messrs. Reeves, however, keep a register at some of their shops, or a good model may be secured from a school of art. The usual pay is one shilling per hour, which includes 10 or 15 minutes' rest. If engaged by the day, seven shillings is usual. These prices apply to adults; children generally get less. In selecting models it is wise to see that they are healthy, well developed, and of good proportion. With female models the student should keep his eyes open to notice the disfigurement caused by the use of corsets. If the student is altogether unacquainted with the female figure, he cannot do better than to take the advice of some teacher who is used to them. Another point to be noticed is the feet. Small boots distort the toes, and high heels crush them. Unfortunately, this will be met with very frequently, particularly in women. Women who have had offspring are, as a rule, not suitable for the student.

Clay. While modelling, the clay should be kept in a zinc-lined trough with a cover, or it may be kept in tubs. In the latter case, attention must constantly be given to it to prevent it hardening from want of moisture. To keep the figure in good condition, it is very convenient to have a rigid cover for it. The frame for this is best made by a joiner, and it should be of such dimensions as will allow it to be dropped over the figure and rested on the board upon which the plinth has been made. The framework should be made as shown in **30**. Inside it should be nailed a covering of flannelette, or old thick sheeting—in short, anything that will hold water. New material is not suitable as a rule, because the water runs out of it very soon. On the outer side of the framework some sort of waterproof sheeting should be tacked. India-rubber sheeting is best, but expensive. American cloth, if good, will serve as well, though it is never quite so durable. When covering up the work, the inside material should be syringed well. It is not necessary then to put water upon the clay model. Avoid this whenever possible, as it washes the fine material from the surface of the clay and makes it gritty.

Continued

THE RULE OF JULIUS CÆSAR

Character of Cæsar. The Catiline Conspiracy. Cæsar's Conquests in Gaul, Britain and Spain. Rise and Fall of Pompey. Cleopatra

Continued from page 1384

By JUSTIN McCARTHY

THE new man who was to arise in the political life of Rome, and to make a greater impression than had ever been made, or was ever to be made while Rome was a ruling State, was Caius Julius Cæsar. He had been in exile for some time during the rule of Sulla, and on the death of Sulla he returned to Rome.

Julius Cæsar. Cæsar had come into disfavour with Sulla because he had married Cornelia, a daughter of Scinna, and when Sulla demanded that he should divorce his young wife and seek another alliance, Cæsar had firmly refused, declaring that he preferred exile from Italy to the betrayal of the woman he loved. His relatives were powerful Patricians, and through their influence he was saved from the extreme measure of Sulla's wrath. The autocrat consented to allow him to go into exile, but it was told at the time that he expressed at once his contempt for what he regarded as Cæsar's love-weakness, and his knowledge of his power by warning the Patricians that " the boy in petticoats " would prove to be another Marius to the ruling orders.

Cæsar, who was born a century before the Christian Era, was then twenty-two, and was the son of a Roman prætor. He had been well trained for a military career, and did excellent service in many wars. He associated himself in Rome with the popular party, and soon achieved a marvellous success as an orator. Cicero, one of the greatest orators in the world's history, is said to have paid a generous tribute to the genius of the rising young man. " Which of us," he asked, " could claim to be the equal of Cæsar in oratory even among those who are orators and do not strive to be anything else ? "

Cæsar's Versatility. Cæsar's claims to fame are such as no other man of the ancient or modern world ever possessed. Among warriors and conquerors he ranks with the very highest—with Alexander in the ancient world and with Napoleon in the modern. He was one of the greatest writers of his day, and during the whole of his ever active life he found time for the production of great historical and literary books written in the finest Roman prose. His short poems and epigrams—some fragments of which are preserved—are faultless, and some of his jests and sarcastic comments were recorded by his friends as were those of Dr. Johnson, and afford much amusement to modern readers.

He was a statesman of the highest order, and although in his wars he sometimes yielded to the barbaric influences of his time, yet when he obeyed his own impulses he invariably showed himself a man of clemency and mercy. When in the intervals of his earlier wars he made himself a powerful figure in Roman political life, he took the popular side, and opposed the influence and the malpractices of the Senate and the Patricians.

The Catiline Conspiracy. One of the most important events of this time was the Catiline conspiracy. Apart from its historical importance, it will always have a deep interest because it gave occasion for the display of some of the great qualities of Cæsar and Cicero.

Catiline was a ruined noble, who belonged to a Patrician family which had sunk into poverty, and which he helped to bring still lower by the vices and crimes of his youth and early manhood. He had great ability, indomitable courage, and a fascinating power which won him many adherents. He early showed ambition to distinguish himself in public life, and though he made no efforts to improve his morals, he devoted himself to the quest of distinction in public affairs. He was elected Prætor in 68 B.C., and in the next year was appointed Governor of Africa ; but when he became candidate for the Consulship in 66, he was declared disqualified because of an impeachment brought against him for oppression and maladministration in his province.

This disappointment filled him with an impatient desire to make himself a power in the State—by foul means if not by fair. He organised a great conspiracy, by which he hoped to become master of the State. He saw that there was opportunity for a revolution because of the general discontent, and the want created among the people by the incessant struggles between the aristocratic and democratic factions, and he knew that many of the aristocrats, especially the followers of Sulla, were ready for any attempt to recover their lost power. His revolutionary plans were in preparation during the Consulship of Cicero, but Cicero was privately informed that some dangerous plot was threatening the public peace.

Catiline proposed to begin his scheme by putting Cicero to death, but Cicero was warned of his purpose by the mistress of one of the conspirators. When, therefore, an attack was made on his house, the conspirators found him ready to receive them. Some were made prisoners, and the others were driven away.

Catiline's Escape from Rome. The news of this outrageous attempt soon spread over Rome. Catiline still was not dismayed, he actually appeared in the Senate two days after the attempt and its failure. His audacious appearance there was the occasion for Cicero's famous speech in denunciation of him, which ranks among the world's greatest orations.

Catiline's attempts to defend himself were drowned by the interruptions and execrations of the Senators, and he found that his only chance of safety lay in flight from Rome.

He had collected large forces, and endeavoured to become the open leader of a revolution. On the flight of Catiline, Cicero ordered the arrest of some of those he believed to be his fellow-conspirators. They were found guilty, condemned to death with hardly even the form of a deliberate trial, and executed the same night. Julius Cæsar opposed these irregular proceedings in a speech which for eloquence and argument will compare well with any speech of Cicero's.

There were rumours at the time that Cæsar had himself been inclined to favour the conspiracy, but nothing in his career gives any excuse for the accusation. The manner in which he stood up for the sanctity of law and the fair trial of every man, in spite of the appearances against him, was honourably characteristic of Cæsar. Catiline gathered his forces around him in one of the Italian provinces, and an army of the Republic was sent against him. In the January of 62 B.C. a fierce battle was fought. Catiline was completely defeated, and, fighting to the last, was left a corpse on the field. The story of the conspiracy and its suppression is the subject of one of the famous works of Sallust, the great Roman historian.

Pompey. Another man was in the meantime rising into prominence. This was Cneius Pompeius Magnus, whom English historians have habitually called Pompey, a name which we shall give him in our course. Pompey in his youth had fought in the civil war against Marius, had supported Sulla, and had reduced to nothingness Marius' party in Sicily, Spain, and Africa. He belonged by birth to the aristocratic order, but after a while he took up the popular cause, and helped to restore the institute of the Tribuneship.

He had done great service by the suppression of piracy in the Mediterranean, and had conquered Mithridates, the sovereign of Parthia, in Asia, in the last war waged by the Romans against that ever-invading sovereign; he made Syria a province of Rome, and captured the city of Jerusalem.

After these events he was welcomed in Rome, for the third time, with a triumphal reception. He began, however, to be distrusted by the aristocratic party, who were possessed by the natural dread that Pompey was striving to make himself absolute master of Rome. He then formed a political alliance with Cæsar, and these two, in conjunction with Crassus, a great millionaire, formed the famous first Triumvirate, in 60 B.C. To strengthen the alliance Cæsar gave his daughter Julia, who had been promised to Brutus, to Pompey in marriage.

Cæsar in Gaul and Britain. Then came Cæsar's great successes in Gaul and in Britain, which kept him out of Rome for many years. The story of his conquests in Gaul and Britain is best told in his own histories, which would have made him famous if they had been his only claim to renown.

By the time Cæsar returned to Rome, Pompey, whose wife, Julia, was now dead, had come to believe Cæsar his most dangerous rival in popular favour, and had gone over once again to the side of the aristocrats. When Cæsar's return to Italy was expected, Pompey persuaded the Senate that Cæsar was determined to seize supreme power over the State; and the Senate, yielding to his advice, called upon Cæsar to disband his army, and thus prove his submission to the existing constitution.

Cæsar, who was now in Italy, although not yet upon Roman soil, refused to obey, and was supported with enthusiasm by his conquering legions. He appears to have had a moment of hesitation, and indeed the risks opposing his further march were such as to call for the gravest consideration. The Roman forces over which Pompey now had full command far outnumbered the legions of Cæsar. The moment of hesitation soon passed, and Cæsar crossed the Rubicon, a small river dividing the province which he then occupied from the actual dominions of Rome.

The Fate of Pompey. That crossing of the Rubicon, in itself a most momentous event in the history of Rome, bequeathed a proverb to the whole civilised world, and it is a common phrase at the present day that when a man decides on taking some momentous step he is crossing the Rubicon. The fate of Pompey was soon decided. Many battles were fought; Pompey withdrew into Greece with an army still large and powerful. Cæsar crossed over to Greece, and in one battle had the worst of it, but on the plains of Pharsalia, in 48 B.C., the final battle was fought, and Pompey received a most decisive defeat. He sought refuge in Egypt, but was put to death there by order of the ministers of Ptolemy, the young King of Egypt.

Ptolemy. Ptolemy was the son of the preceding Egyptian sovereign, Ptolemy Auletes, and was the younger brother of the celebrated Cleopatra. The father, when dying, appointed the son and daughter conjoint rulers. Quarrels soon arose between the young sovereigns, and Cleopatra was driven from the kingdom. While this quarrel was going on, Pompey arrived at the Egyptian shore, and, casting anchor, asked for permission to make a landing. The nobles surrounding the young monarch regarded the condition of things as critical and dangerous for their master and themselves. They feared that by offering their hospitality to Pompey they would make Cæsar their enemy, and they knew enough of what was going on in the world to know that Cæsar would be the most dangerous enemy Egypt could have.

But they were equally afraid that if they refused Pompey a landing the result would be that he would join Cleopatra, who was already raising large bands of partisans to maintain her claim to a share in the Egyptian sovereignty, and that another danger would thus threaten Ptolemy and his supporters.

Assassination of Pompey. There seemed to be but one way out of the difficulty—a way by no means uncommon then in Eastern and even in Western lands. Their plan was to get rid of Pompey by putting him to death. Pompey was granted permission to land. and, as he set foot on the shore, he was instantly killed. Cæsar, in pursuit of Pompey, arrived in Egypt soon after, and the leading accomplices in the murderous deed believed that they could best conciliate the conqueror by presenting him on his landing with the head of Pompey. They were doomed to disappointment. Cæsar, sickened at the sight, turned away in disgust. and broke into tears at this evidence of his old friend's fate. He insisted that the murderer must be instantly put to death, and his demand had to be promptly carried into execution.

The death of Pompey took place in the September of 48 B.C., when he had just entered on his fifty-eighth year. He was undoubtedly a man of great military capacity, with some gift of statesmanship, and probably the only Roman who could be regarded as a possible rival to Julius Cæsar.

After the death of Pompey. Cæsar did not immediately return to Italy, but seems to have been possessed by a desire to bring the disturbed condition of Egypt into better and more settled order. He had with him but a small force of some 4,000 men, but he settled in the capital and set himself to work to bring about a reconciliation between Ptolemy and Cleopatra, and to prevail on them to continue their joint rulership of the country. The people of Alexandria, made up of various nationalities, seemed little inclined to accept the leadership, or, at least, the absolute control, of a stranger like Cæsar. There was a military rising against him, which, having the support of the native army and of many leading men, seemed for a time formidable. Cæsar encountered the crisis with his usual undaunted courage and cool power of observation. He sent at once to Asia for military reinforcements, and, awaiting the coming of these, entrenched himself as well as he could.

Cæsar and Cleopatra. Some engagements took place, during one of which Cæsar only contrived to save his life by swimming to one of his own vessels; but he was able, through whatever difficulties, to keep his navy afloat and to inflict much injury on the Egyptian fleet. The desired reinforcements at last arrived, and before the struggle had gone much farther the dispute between the young sovereigns was ended by the death of the king, and many others, in an attempt to escape by sea from Cæsar's conquering army. The result was the entire submission of the Alexandrians to Cæsar's power. Cæsar was clement in his dealings with the subdued enemy, and by his command Cleopatra was restored to her throne.

It has been accepted as part of history that Cleopatra had fallen in love with the conqueror, and that Cæsar lingered long in Alexandria because of this romantic episode in his life. He had still to conduct military operations, for a war had broken out in Asia Minor, and one of his lieutenants had been defeated by Pharnaces, the son of Mithridates. Pharnaces was engaged in an attempt to restore his father's dominion. Cæsar set out at once on an expedition against him, and, in a campaign lasting only five days, completely defeated him. This was the success which he described in his celebrated despatch to Rome in the words, "Veni, vidi, vici." He then hastened back to Rome, but by the time he arrived those who had supported Pompey once more rose against him. Some of the Roman legions, still treasuring their allegiance to Pompey, mutinied, and marched on Rome. Cæsar made prompt arrangements for the defence of the city. and then, suddenly leaving Rome, presented himself to the mutinous legions. The leaders of the mutiny declared that their only desire was to be released from their service. Cæsar, inspired by one of those impulses of combined clemency and foreseeing statesmanship so characteristic of him, told them that they were free to go, with the assurance that when he and his legions should have completely overthrown their enemies the discharged soldiers, now released at their own wish, would be free to claim their share of the hostile spoils and lands, although, having been discharged, they could not appear in the public triumph.

Cæsar's Diplomacy. According to all received traditions, Cæsar made a deep impression on his listeners by addressing them as "citizens," and no longer as "fellow soldiers." This deliberate change of denomination pierced the very hearts of the soldiers, filling them with deepest pain at the thought that, while they were allowed to receive their share of the spoils, they were no longer regarded by the commander as his comrades in war. They abandoned all their demands, unanimously besought him to restore them to their former position in his service, and to allow them to share with him the honours of the victory. Cæsar then returned to Africa, and, by his military skill and promptness in taking advantage of every opportunity, he triumphed completely over his opponents.

The cause of Pompey was now wholly lost, and Cato the Younger, who had long been an inveterate opponent of Julius Cæsar, resolved to give up life rather than submit to the victor. After a night spent in reading Plato's "Phædo," he deliberately stabbed himself in the breast and died.

Rome's Reception of Cæsar. Cæsar received four public triumphs in Rome for his successes in Gaul, in Asia Minor, in Egypt and other parts of Africa; but he was offered no public honour for his victory at Pharsalia, because of the recognised custom that no Roman was to have a public celebration for a victory won over his fellow Romans in civil war. Cæsar fully appreciated the significance of this principle, and could have felt no desire to claim a triumph for a victory over his fellow-citizens in a war forced upon him by the necessities of his public station and military duty. These ceremonials were the culmination of Cæsar's career. He was now supreme master of Rome, while still in the prime of life. He had passed his youth, for the most part, in pleasure, luxury and dissipation, although he had ever shown a deep interest in letters and in arts.

When he rose in the military service he renounced all his earlier follies, gave up wine, and devoted himself to his duties as a commander and as a leading public man, and to the literary work he loved so well. He had proved through all his wars that he was endowed with that rare and almost marvellous foresight and that clear calculation of possibilities which enabled him to see that, whatever might be the difficulties surrounding him, no matter how he might seem to be on the verge of defeat, it was still within his power to carry to success the task he had undertaken. We have already shown that he was not only a great military commander but also a great orator and a great statesman. In the Senate he had no rival. When after the wars which he had lately carried on he returned to Rome he became at once—in fact if not in title—the ruler of the State.

Condition of Rome. Rome in the meantime had fallen into an alarming condition of political corruption, and was rent to the heart by the selfish struggles of hostile political parties. Cæsar devoted himself to the restoration of order, to the healing of political corruption, and to the foundation of a stable Commonwealth on principles of civil equality and freedom. He made, from the first, no difference in his treatment of friends and enemies. He allowed no penalties to come upon the followers of Pompey, and he proclaimed his intention to introduce an entirely new chapter into the history of the long distracted State. He became, above all things, a reformer; he did his best to find employment for the poorest classes on public works, and by organising a suitable system for the emigration of able-bodied men to the Roman colonies, which were especially in need of such help towards their development. He put into operation great plans for the draining of marshes, for the construction of harbours, for the deepening of beds of rivers. He initiated measures for the improvement of the colonies, for making the Senate larger and more thoroughly representative, and also an efficient agent of the ruling authority rather than the mere instrument of the strongest political party.

The Change in the Calendar. One great accomplishment of Cæsar's genius was the entire reform of the calendar, which up to that time was in a state of bewildering confusion. The length of the days in the different seasons had not been settled, and even the divisions of months and years had been left to chance, or to regulations which best suited the convenience of each ruling party. There are students of history who regard the reform which Cæsar thought out and established as the most remarkable accomplishment of his whole career.

Many a man may believe that, if he had had the training and the opportunity, he might have turned out a great military commander or a great statesman; but such a man would readily acknowledge that if he had been called upon to evolve out of the depths of his moral consciousness an entirely new and exact calendar of the days, months, and years, he would have had to give up the task in despair. Cæsar, however, accomplished the work, and set up a calendar which civilisation accepted for more than fifteen centuries. So little was then known of the actual science of astronomy that an exact calendar was not a possible achievement, and it was left for a modern period, with its immense increase of knowledge of such subjects, to perfect the work which Julius Cæsar had brought into existence.

War in Spain. Cæsar was interrupted in this task by the outbreak of a war in Spain, where the sons of Pompey were rallying their forces for a new revolt. He went to Spain, brought the struggle to an end, and then returned to Rome to continue his peaceful work. He was welcomed with a new public triumph. Then, at last, he was proclaimed in name what he had long been in fact—"Imperator," or ruler of the State. He was offered the title of King more than once, but he always refused it, acting in the spirit of his declaration when the proposal was first made to him. "I am not a king; I have no wish to be a king; I am Cæsar." The remainder of Cæsar's reign—for it must be described as a reign—brought Rome to her highest position in the history of the world. His rule as a reformer was, indeed, interrupted by some wars, but it may easily be imagined that during these campaigns he was, as he had been during his campaigns in Gaul, still contemplating and planning projects for the regeneration of the Roman State.

Continued

Continued from page 1397

STRENGTH OF STONES, BRICKS, & CEMENTS

Crushing Strength and Safe Working Stress on Stone. Tensile and Transverse Strength. Bricks and Brickwork. Brick Piers. Lime. Cement. Concrete

By Professor HENRY ADAMS

Crushing Strength of Stone. The general characteristics of the principal varieties of building stones are described in pages 528–534. It will be remembered that while some are crystalline and fairly homogeneous, the majority are more or less laminated or built up by stratification, so that for durability it is necessary to lay the blocks in such a position that the pressure upon them is perpendicular to the stratification. This usually means that they must stand on their natural bed, or in a similar position to that they occupied in the quarry. They are, therefore, tested in this position by direct compression; but, like other materials, the samples are specially selected and prepared for testing, so that the maximum result is obtained, and the figures so found bear only a distant relation to the crushing values of stone used in the ordinary manner of preparing and bedding in the construction of a building. The size usually adopted for testing is 3 in. to 6 in. cubes, dressed perfectly true and smooth, and placed between pieces of pine ⅜ in. thick, so that the stone has every facility allowed for showing a high initial strength. It is usual to note the load at which cracking commences, and then to continue the pressure until crushing takes place. These figures are then reduced to the equivalent tons per square foot.

Safe Working Stress. The safe working stress will vary from one-hundredth to one-twentieth, according to the stone and the circumstances of its use, and no general rule can be laid down. In many cases the stone in use will have to bear only a comparatively small load, its size depending upon conditions other than the load to be carried; but whenever its absolute supporting power is in question it must be carefully selected, truly dressed, and well bedded. By way of illustrating the contingencies to be met, it may be stated that carefully-prepared samples of granite may crush with loads varying from 150 to 2,420 tons per square foot, but from 15 to 25 tons per square foot is the greatest load that can be safely put upon this material in practice, and even then failure may occur from want of sufficiently careful bedding.

Tensile Strength of Stone. Stone is never used under tensile stress, but a few varieties have been tested by way of experiment. The ultimate tensile strength of some well-known stones in tons per square foot is as follows:

Craigleith sandstone	29 tons
Arbroath (paving) sandstone	80 ,,
Humbie sandstone	18 ,,
Caithness sandstone	68 ,,
Binnie sandstone	18 tons
Chilmark limestone	32 ,,
White statuary marble	35 to 46 ,,
Whinstone	94 ,,
Slate	617 to 823 ,,

Transverse Strength of Stone. For lintels, hanging steps, and landings, stone is subject to a transverse stress, but it is very unusual to test it for the modulus of transverse rupture. In the absence of data of this kind, the tensile strength may be made use of when a calculation is required. The only figures available for modulus of rupture appear to be:

Sandstone ..	1,100 to 2,360 lb. per sq. in.
Slate	5,000 to 5,040 .. ..

The tables appearing further on give the range of strength and weight of the usual building stones.

Physical Tests of Stone. For external use it is most important that a building stone should weather well—that is, it should not decay prematurely upon exposure to the moisture and acids in the atmosphere. The best test of this quality is to inspect buildings where the particular variety and from the same bed in the quarry has been in use for a long period; but it must be borne in mind that a given variety may endure well in the comparatively pure air of the country or a small provincial town, and be quite unsuitable for use in a manufacturing town or large city. This applies especially to limestones and to sandstones, where carbonate of lime is the principal cementing material; and a very fair idea of the durability of a stone in a town atmosphere may be formed by placing a piece of the stone in a solution containing 1 per cent. of sulphuric acid and of hydrochloric acid, and allowing it to remain for several days. If disintegration occurs, the stone will not be durable.

Smith's and Brard's Tests. What is known as Smith's test is a good one for finding the quantity of earthy matter contained in stones which may be under consideration. The stone is taken in a moist state, and small chippings knocked off; these are placed in a glass of clear water and allowed to remain undisturbed for some time. The contents are then agitated by giving the glass a circular movement with the hand. If the water remain practically clear, the stone is of well-cemented particles, but if the water become clouded, the degree of murkiness will give the amount of uncrystallised earthy matter contained in the stone. If another piece of the stone be dried and weighed and then boiled in Glauber's salts (*sodium sulphate*), and then the salt allowed to crystallise in it, the loss of weight after drying again will represent the damage likely to arise from the effects of frost. This applies chiefly to

STRENGTH AND WEIGHT OF STONE

Variety.	Compressive Strength. Tons per sq. ft.		Specific Gravity.	Weight per cub. ft. lbs.	Weight per cub. in. lbs.
	Cracking commences.	Ultimate crushing.			
GRANITES :					
Aberdeen (grey)	350	500 to 1,400	2·63	164	·095
Ballyknocken (Irish)	—	200	2·71	169	·098
Cheesewring (Cornish)	200 to 295	322 to 403	2·93	183	·106
Cornish	—	400 to 955	2·66	166	·096
Irish (various)	—	150 to 860	2·72	170	·098
Penryn Cornwall)	—	1,285	—	—	—
Peterhead (red)	400	400 to 1,600	2·66	166	·096
Rivals (Carnarvonshire) ..	—	2,330 to 2,420	—	—	—
SYENITIC GRANITES :					
De Lank (Cornish)	280 to 349	363 to 1,170	2·88	180	·104
SYENITES :					
Guernsey	280 to 761	830 to 1,150	2·96	185	·107
Herm (near Guernsey) ..	— to 686	120 to 956	3·0	187	·108
Mount Sorrel	—	820	2·66	166	·096
BASALTS, ETC. :					
Felspathic Greenstone ..	—	1,100	—	—	—
Hornblendic ,, ..	—	1,580	—	—	—
Irish (various)	—	500 to 1,960	—	—	—
Shepton Mallet	—	2,590	—	—	—
Whinstone	—	530 to 770	2·76	172	·099
SLATES :					
Cornwall	—	—	2·51	157	·091
Killaloe (Irish)	—	1,970	—	—	—
Valentia ,, ...	—	720	—	—	—
Welsh	350	730 to 1,050	2·88	180	·104
Westmorland	—	—	2·79	174	·101
SANDSTONES :					
Ackworth	—	389	2·26	141	·081
Arbroath (paving)	—	500	2·48	155	·09
Bramley Fall	120	238 to 390	2·28	142	·081
Bridge or Grinshil	—	209 to 327	1·96	122	·071
Caithness	—	415	2·64	165	·095
Closeburn (red freestone) ..	—	400 to 626	2·61	163	·094
Corsehill	—	445 to 635	2·28	142	·081
Covo	—	650	2·16	135	·078
Craigleith	150	200 to 862	2·32	145	·084
Cromford	—	497	2·72	170	·098
Darley Dale	412	450	2·37	148	·086
,, Top	—	516	2·23	139	·08
Dean Forest	—	530	2·43	151	·088
Doonagore or Shamrock ..	1,576 to 1,955	1,710 to 2,214	2·72	170	·098
Drumkeelan	—	50	2·47	154	·089
Dunmore	—	435	2·29	143	·083
Duntrune	—	1,024	2·72	170	·098
Grimshill	—	—	2·24	140	·081
Kenton	220	320	2·32	145	·084
Park Spring	252	486	2·43	151	·088
Robin Hood	—	575	2·31	144	·084
Runcorn	—	140 to 514	2·07	129	·075
Scotgate Ash or Head ..	—	734	2·45	153	·089
Watson-stone	—	1,710	2·79	174	·101
Whitby	—	70	2·11	132	·076
York (paving)	130	370	2·51	157	·091
DOLOMITES :					
Red Mansfield	130	326 to 600	2·37	148	·086
White Mansfield	165	336 to 461	2·34	146	·085
LIMESTONES :					
Beer..	—	162	2·18	136	·079
Chalk	5	26 to 70	1·87 to 2·79	117 to 174	·068 to ·101
Hopton Wood	—	444	2·53	158	·091
Kentish Rag	—	—	2·66	166	·096
Limerick	—	560	2·64	165	·095
Listowel	—	1,200	2·76	172	·099
OOLITIC LIMESTONES :					
Ancaster	110	150 to 184	2·24	140	·081
Box Ground (Bath)	40 to 82	75 to 95	1·97	123	·071
Chilmark or Tisbury	165	400	2·45	153	·089
Coombe Down (Bath) ..	—	117	1·86	116	·067
Corsham Down (Bath) ..	—	94	1·97	123	·071
Doulting Freestone	106 to 130	140 to 160	2·05	128	·074
Ham Hill	100	166 to 269	2·24	140	·081
Ketton	100	102 to 312	2·06	128	·074
Ketton Rag	228	578	2·48	155	·09
Portland (true roach)	—	260	2·48	155	·09
,, (Whitbed)	90	205	2·32	145	·084
,, (Curf)	—	—	2·31	144	·083
,, (Basebed)	90	287	2·20	137	·079
Purbeck	—	580	2·64	165	·095
Seacombe	—	—	2·40	150	·087

porous or absorbent stones, which may hold moisture unduly. This is known as Brard's test. It has, however, been pointed out by C. H. Smith that the salt only crystallises in the pores without expansion, while water expands considerably as it freezes.

Strength of Bricks. The strength of a brick varies not only with its composition, but with the degree of burning to which it has been subjected. Underburnt bricks have little initial strength and crumble away on exposure to the weather. London stocks, being formed of brick earth mixed with coke breeze, the burning out of the breeze leaves the bricks somewhat porous and therefore less able to resist pressure than the denser kiln-burnt or machine-pressed bricks, although this is partly compensated by the higher temperature tending to vitrify them. Bricks are tested in compression only, the frog being filled up with plaster of Paris and both sides brought to a level surface with the same material, and then the whole placed between pieces of pine ⅜ in. thick. [See Tables, page 1520.]

Strength of Brickwork. The strength of brickwork depends very largely upon the strength of the mortar, and it is therefore very desirable that the quality of the mortar should vary with that of the bricks in order to obtain the best result.

Hurst's "Architectural Surveyors' Handbook" gives the safe load on stock brickwork in Portland cement as 5 tons per foot super ; in lias lime mortar as 3 tons per foot super ; and in grey lime mortar as 1½ tons per foot super. These values, although low, are no doubt sufficient to put upon ordinary brickwork without special supervision.

In the author's practice he allows the safe loads in accompanying table for average cases where continuous supervision is exercised during building, permitting them sometimes to be increased by 50 per cent. in special cases of practically constant dead loads.

Brick Piers. Hurst gives a table of the reduction which should be made in loading piers according to the number of times the height exceeds the least width, but the reduction named is very inadequate. In the writer's opinion an independent pier of brick or stonework should not in any case exceed in height 24 times its least width; then, if W = the safe load on the material up to six diameters high, and r the ratio of height to least diameter, the coefficient of reduction would be given by the formula $\frac{24 - r}{18}$. For example, if 4 tons per square foot be the given safe load upon certain brickwork, this may be allowed on a pier up to a height of six times the least width; but if it be required to carry it up to a height of 12 times the least width, the coefficient of reduction would be $\frac{24 - 12}{18} = \frac{2}{3}$, and $4 \times \frac{2}{3} = 2\frac{2}{3}$ tons per square foot safe load. When bonded to a wall throughout its height, a pier is materially strengthened, but it is impossible to say definitely to what extent the load may be increased, as it depends so much upon the nature of the bonding and the quality of the workmanship.

SAFE LOAD ON BUILDING MATERIALS

Material.	Tons per Foot Super.	
Granite	20 = $\frac{1}{15}$	fracture load.
Portland and compact limestone ..	15 = $\frac{1}{15}$	"
Hard York stone	12 = $\frac{1}{10}$	"
Limestone (ordinary)	6 = $\frac{1}{10}$	"
And with stone template interposed:		
Blue brick in cement	9 = $\frac{1}{8}$	"
Stock brick in cement	6 = $\frac{1}{8}$	"
Stock brick in lias mortar ..	5 = $\frac{1}{4}$	"
Stock brick in grey lime mortar ..	3 = $\frac{1}{4}$	"
And below the brickwork :		
Portland cement concrete (6 to 1)	5 = $\frac{1}{8}$	"
Lias lime concrete (4 to 1) ..	3 = $\frac{1}{6}$	"
Gravel and natural compact earth	2 —	"
Made ground rammed in layers ..	1 —	"

Clay requires special consideration, and no general rule can be laid down. Pressed gault, Fletton, and Leicester red bricks are intermediate in strength between London stocks and Staffordshire blue bricks.

STRENGTH OF BRICK PIERS BY EXPERIMENT (Hurst)

The height being less than 12 times the least width.

Varieties of Bricks.	Weight per Foot Super at which Cracking Commenced.
Hard stock bricks, best quality, set in Portland cement and sand, 1 to 1, 3 months old	40 tons
Ordinary well-burnt London stocks, set in Portland cement and sand, 1 to 1, 3 months old	30 "
Hard stock bricks, Roman cement and sand, 1 to 1, 3 months old ..	28 "
Hard stock bricks in lias lime and sand, 1 to 2, 6 months old	24 "
Hard stock bricks in grey chalk lime and sand, 1 to 2, 6 months old ..	12 "

For final and absolute crushing the above loads might require to be multiplied by 1½ or 2, but failure must be considered to occur when the cracking commences.

It may be taken that the working loads ought not in any case to exceed one-fourth of the load at which fracture commences, unless special care be taken in supervision during construction, and then for dead loads only the material might be loaded up to one-third of the fracture loads.

R.I.B.A. Experiments. The Royal Institute of British Architects made some valuable experiments on the strength of brick piers at the West India Docks in 1896-7. The piers were 6 ft. high and 18 in. square, built in the ordinary manner; some were even too ordinary, the interior of hard brick piers being filled in with common brick, but

STRENGTH AND WEIGHT OF STONE—continued

Variety.	Compressive Strength. Tons per sq. ft.		Specific Gravity.	Weight per cub. ft. lbs.	Weight per cub. in. lbs.
	Cracking commences.	Ultimate crushing.			
Magnesian Limestones :					
Bolsover Moor	320	480	2·42	151	·088
Park Nook	118	278	2·20	137	·079
Roche Abbey	100 to 150	100 to 250	2·23	139	·08
Marbles :					
Brabant (black)	—	590 to 1,360	2·69	168	·097
Devonshire (red)	300	475	2·61	163	·094
Galway (black)	—	1,300	—	—	—
Italian (white)	350	620 to 1,400	2·72	170	·098
Kilkenny (black)	—	970	2·74	171	·099
Statuary (white)	—	200 to 390	2·72	170	·098
Artificial Stones :					
Ford's Silicate-of-lime	—	600 to 700	—	—	—
Ransome's	—	450 to 640	2·16	135	·078
Stuart's Granolithic	—	562	2·31	144	·083
Victoria	—	414 to 550	2·24 to 2·56	140 to 160	·081 to ·093

CRUSHING STRENGTH OF BRICKS

Variety.	Compressive Strength. Tons per sq. ft.		Specific Gravity.
	Crushing Commences.	Ultimate Crushing.	
Best London Stocks	84 to 133	103 to 180	1·84
Common Stocks	40 to 60	80 to 120	1·84
Place Brick (underburnt)	10 to 15	33	—
Bourne Red Wire-cut	165 to 258	240 to 359	1·94
Red Brick, common	35	138	2·08
Fareham Reds	38·5	103	—
Fareham Red Rubbers	4	25 to 52	2·16
Fletton Light Red	126 to 199	169 to 239	—
Gault	49	135	—
,, White, Wire-cut	40·5 to 119	145 to 198	—
,, Pressed	30	177	—
Staffordshire Common Blue	46 to 240	137 to 464	—
,, Dressed ,,	55	403	—
,, Pressed ,,	78	275	—
White Glazed Bricks	69 to 166	166 to 174	—
Brown ,, ,,	58	83	—
Terra-cotta Blocks	—	100 to 260	1·95
Dutch Clinkers	—	—	1·71
Paving Bricks	—	—	1·97
Stourbridge Fire-brick	90 to 157	110 to 209	2·2
Welsh Fire-brick	56	208	1·97 to 2·4

SIZE AND WEIGHT OF BRICKS

Variety.	Size in inches.			Weight lbs.	Weight per 1,000 in cwts.
London Stock	8·75	4·25	2·75	6·81	60·75
Red Kiln	8·75	4·25	2·75	7·0	63
Fareham Reds	8·5	4·15	2·6	6·3	56·2
,, Rubbers	10·9	4·8	2·9	8·8	78·5
Lancashire Red Pressed Facing Brick	9·0	4·5	3·0	8·9	80
Leeds Pressed	9·5	4·5	3·5	10	89
Burham Wire-cut	8·6	4·0	2·6	5·4	48·2
,, Pressed	8·75	4·2	2·7	6·1	54·5
Suffolk Brimstone	9·0	4·6	2·6	6·8	60·7
,, White	9·2	4·3	2·6	6·3	56·2
Staffordshire Paving	9·0	4·5	3·0	8·9	80
,, (thin)	9·0	4·5	2·0	6·1	55
Tipton Blue	9·0	4·5	3·0	10	89
Adamantine Clinker	6·0	2·5	1·75	2	18
Dutch Clinker	6·25	3·0	1·5	1·55	14

this being discovered in time, they were rebuilt. Tested by hydraulic pressure when six months old, the results were as given in the following table. All the bricks were wire cut and without frogs.

Material.	In Mortar 1 to 2.		In Cement 1 to 4.		Average strength of single brick.
	Commence to fail.	Final collapse.	Commence to fail.	Final collapse.	
	Tons per sq. ft.	Tons per sq. ft.	Tons per sq. ft.	Tons per sq. ft.	Tons per sq. ft.
London stocks	4·18	10·41	7·22	16·03	84·27
Gault ..	5·00	21·82	6·98	17·98	182·2
Ditto ..	6·16	22·03	7·08	17·51	—
Leicester red	15·20	29·93	17·87	67·36	392·1
Ditto ..	16·11	31·55	21·82	49·54	—
Staffs. blue ..	22·43	69·22	29·45	84·47	701·1
Ditto ..	21·42	79·39	16·91	61·14	—

Tests of short walls of similar brickwork and under similar conditions gave the crushing loads in tons per square foot as follows :

Bricks.	Lime Mortar 1 to 2	Cement Mortar 1 to 4
Stocks	18·63	39·29
Gault	31·14	51·34
Fletton	30·68	56·25
Leicester red	45·36	83·36
Stafford blue	114·34	135·43

Closers in the bonding are found to be a constant source of weakness, and it is therefore desirable to use "Dutch bond" where it is suitable—that is, a three-quarter brick at the angle instead of a quarter brick closer next to the corner header. Bricklayers are, as a rule, more concerned to show a good appearance on the outside than to look upon the work as requiring to be absolutely solid throughout, and a very large margin is required for contingencies when heavy loads are to be carried.

Strength of Lime Mortar. Grey lime, made from the lower chalk and called *stone lime* in London, is that generally used for mortar for building purposes. It is technically known as a poor lime because it will not bear the addition of much sand, the usual proportion being 1 of lime to 2 or 3 of sand, and it sets slowly on account of the absence of clay in its composition.

It gradually reabsorbs carbonic acid from the atmosphere and gains strength by the lapse of time. Lime mortar is very seldom tested either in compression or tension ; the safe working loads may be taken as 50 lb. per square inch or 3 tons per square foot in compression and one-third of these amounts in tension. The weight of lime mortar, when new, averages 110 lb. per cubic foot, and when old 90 lb. The only record of ultimate tensile stress gives 50 lb. per square inch.

Lias Mortar. Lias mortar made from blue lias lime sets quicker and attains greater strength than grey lime mortar, on account of containing a certain proportion of clay in its composition. It will also set in a damp situation, and is much used in engineering work. The safe working loads may be taken as 150 lb. per square inch, or 9 tons per square foot in compression and one-third of these amounts in tension.

WEIGHT AND SPECIFIC GRAVITY OF LIME.

—	Specific Gravity.	Weight. lbs. per Cub. ft.
Grey chalk lime (lumps) ..	·70	44
Stone lime (lumps)	·88	55
Quicklime (chalk)	·84	53
Lyme Regis (blue lias in lump)	·93	58·5
Lyme Regis (blue lias fresh ground).	·87	54·5
Keynsham (blue lias in lump)	1·0	62·4
Keynsham (blue lias fresh ground).	·84	53

Testing Portland Cement. The tests that Portland cement has to undergo depend to some extent upon the importance of the work in which it is to be used. High-class cement generally has to undergo the following tests. The *fineness of grinding* must be such that, when sifted through sieves of various sizes, the residue shall not exceed :

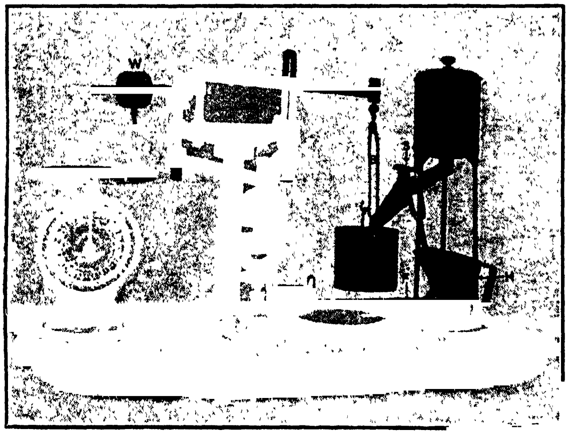
½ per cent. with 50 holes per lineal inch.
5 ,, ,, 75 ,, ,, ,,
12 ,, ,, 100 ,, ,, ,,

The *time of set* when a pat is gauged with the minimum quantity of water at 60° F. and placed on glass shall not be less than eight minutes for the commencement and not more than five hours to set hard. The *soundness*, or freedom from expansion and contraction, is tested by subjecting a pat to moist air and warm water at 120° F. in a Faija apparatus for 24 hours. For *tensile strength* briquettes of neat cement gauged with the minimum of water on a non-porous bed and placed in water 24 hours after gauging, shall carry an average strain of not less than 350 lb. per square inch after three days, 450 lb. after seven days, and 550 lb. after 28 days from the time of gauging.

Weight of Portland Cement. Portland cement was formerly specified by weight, generally from 110 to 120 lb. per Imperial striked bushel, and special precautions had to be taken to secure uniformity of filling and striking to prevent accidental or intentional error. It is now usual to describe it by the specific gravity, say 3·1, and by the method adopted this applies to the ultimate particles, not to the bulk, so that there is no direct comparison between the specific gravity and the weight of a given volume of cement.

Apparatus for Testing Portland Cement. Complete sets of apparatus are provided for conveniently testing cement, as, for example [94], by Messrs. George Salter & Co., of West Bromwich, but for important works it is usual to send samples of each consignment to a specialist. As in testing other materials, so with Portland cement, the time occupied, or the rate at which the load is applied, affects the result; and there are many other precautions that have to be taken to ensure a true comparison between various samples. A diagram of tests made some years ago by Mr. Grant, of the Metropolitan Board of Works, and corrected for probable errors is given in **95**.

Details of the Apparatus. The testing machine [**94**] consists of a japanned cast-iron column, carrying a pair of compound levers, having a combined leverage of 50 to 1. The levers are fitted with tempered steel knife-edges, which rest on polished concave bearings, also of tempered steel, thus obtaining a very sensitive balance. A sliding balance weight for the purpose of setting the levers in equilibrium is fitted to the upper lever. The upper clamp, to receive the cement briquette, is suspended from a knife-edge on the lower lever; the lower clamp is attached to the base of the column, and is adjustable by means of a screw and a small hand-wheel. The supply of shot to the bucket is automatically cut off at the moment the briquette breaks.



94. CEMENT TESTING APPARATUS

To use the machine the levers are set "floating" by means of the sliding balance weight W, the briquette placed in the clamps, the bucket hung on the bridle B, the small hand-wheel screwed down until the end of the lever from which the shot bucket is suspended is as high as it can conveniently be, and the handle H pressed down until the shot flows at the desired rate. Immediately the briquette breaks, the bucket into which the shot has been poured falls upon the lever foot F, the sliding shutter S is released, falls, and cuts off the supply of shot. The bucket and shot are then weighed on a Salter's spring balance, fitted with a special dial, on which the breaking strain is indicated without any calculation. Should the shot become blocked, and cease to flow, a slight tap will restart it. A mixture of shot, No. 6 and No. 10, may be used. The maximum capacity of stress is 1,000 lb.

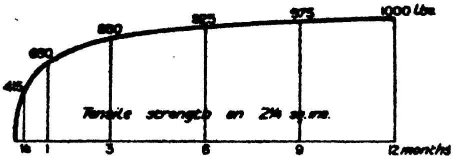
Roman Cement. Roman cement is very little used at the present day. It is chiefly employed for repairing dock and river walls, where they are subject to a rising and falling tide, as the work may be done in portions, and will set thoroughly hard between each tide. It is generally used neat, or, at the most, with an equal part of sand; but the latter reduces the strength considerably. The weight of Roman cement is from 60 to 100 lb. per cubic foot, and has an ultimate tensile strength, when neat, of 120 to 200 lb. per square inch at seven days. When mixed with an equal part of sand, the ultimate tensile strength is reduced to 50 lb. per square inch. A diagram of the strength of Roman cement, from the experiments by Mr. Grant, is given in **96**, but it shows so much irregularity that no reasonable correction can be made, and further experiments are needed.

Cement Mortar. When very strong brickwork is required, as in piers for carrying heavy loads, or in underpinning, or where settlement has to be reduced to a minimum, as in bonding to old work, it is usual to build in Portland cement mortar, the proportion being 1 of cement to 3, 4, or 5 of sand, according to circumstances. It is important that only small quantities should be mixed at one time, and that it should all be used within one hour of making; otherwise, the partial setting and chopping up again will seriously reduce the strength. In testing cement mortar, briquettes are made up of three parts of standard Leighton Buzzard sand to one part of cement by weight, but otherwise treated as the briquettes of neat cement. The average tensile strain they will stand must not be less than 150 lb. per square inch at seven days, and 250 lb. at twenty-eight days, from the time of gauging; but no matter how much greater strength may be developed at the earlier dates, both neat and sand briquettes must develop an increase of at least 50 lb. between each date. [D. B. Butler.]

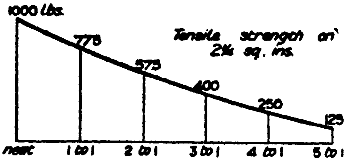
The effect of age on neat Portland cement is shown diagrammatically by **97**, and the effect of mixing sand with the cement is shown by **98**.

Crushing tests of the mortar used in the West India Dock experiments of the Royal Institute of British Architects, referred to on page 1519, gave with—

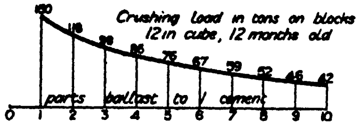
Lime mortar:			
1 to 2, at	4 weeks ..	6·08	tons per sq.ft.
„	12 „ ..	8·73	„
„	24 „ ..	15·72	„
Cement mortar:			
1 to 4, at	4 weeks ..	31·45	„
„	13·7 „ ..	48·52	„
„	24 „ ..	56·15	„



97 *Effect of age on strength of neat Portland cement*

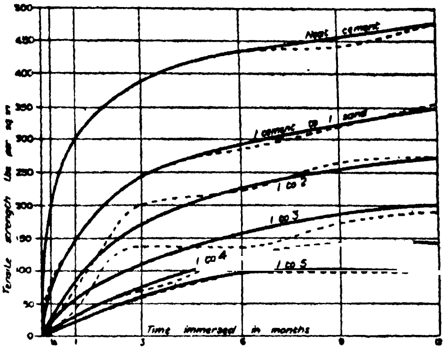


98 *Effect of sand on strength of Portland cement mortar*



99 *Effect of ballast on strength of concrete*

STRENGTH OF PORTLAND CEMENT



95 *Strength of Portland cement (Grant)*

of Roman cement

100 *Strength of Concrete (Grant)*

DIAGRAMS OF CEMENT TESTS

Concrete. Lime concrete, composed of one part of stone lime to six parts of burnt clay ballast, is used by speculative builders under footings of walls, whilst in sound building nothing less than lias lime with broken brick is used; but wherever concrete is required the matrix should be Portland cement. The aggregate may be broken brick or stone, flint ballast, slag, etc., according to local facilities. A certain proportion of sand is always required to fill up the smaller interstices in the aggregate, and the latter should vary in size, to render the mass as solid as possible. The mixing must be very thorough, and for best results the concrete must be gently rammed immediately it is put into position. The variation in strength, according to the proportion between ballast and cement, is shown in **99**, and Grant's experiments are shown by **100**. The safe load may be taken as one-tenth of the crushing weight, unless it be mixed and laid by specialists, when it would probably be equally safe with one-fifth of the crushing weight, the explanation of the difference being that when mixed and laid by ordinary bricklayers' labourers the tabular strength could never be reached, and the factor of safety of 10 would be practically diminished to 5, or less.

The weight of lime concrete is about 120 lb. per cubic foot, and Portland cement concrete 140 lb. per cubic foot.

Continued

OUTLINES OF EDUCATIONAL TOURS ABROAD

Itineraries of Travel in Russia and Greece. Holy Cities of the Greek Church. Hellas, the Home of Culture and the Arts. The Isles of Greece

Continued from page 1486

By J. A. HAMMERTON and WILLIAM DURBAN, B.A.

RUSSIA

The traveller who visits Russia can never know a dull moment. Directly we cross the frontier we plunge into another world. In "Holy Russia" we see the East and the West jostling each other, but never mingling. St. Petersburg is still, as Peter the Great said of it when he founded his new capital, "a window through which the East looks out at the West." Russia is the home of the purest mediævalism in full survival, and everywhere we find ourselves face to face with the customs of the Middle Ages in living presentation. The tourist comes under the spell of the peculiar charms of the enchanting climate, of the "white nights," of the vast and lovely forests, of the immense, flowery steppes, of the quaint Byzantine ecclesiastical art, of the picturesque architecture, and of the genial and hospitable people, with their passionate love of music, their singular superstitions, and their beautiful language.

A Fortnight in Russia. A holiday of two weeks may well be undertaken by those who wish simply to see the old and new capitals, with Nijni Novgorod and Kazan thrown in, or else with a short stay at Warsaw and Cracow in Poland on the way out or on the return journey. In fourteen days, exclusive of the journeys to and from Russia, which together will take nearly a week, a very enjoyable quick round may be accomplished, and Moscow, St. Petersburg, and one or two other points may be visited and fairly studied. Indeed, supposing a tourist visiting Germany can spare only a week in Russia, he may very well spend seven days in St. Petersburg and Moscow, although he cannot possibly do more.

First Day. The first six days would be devoted to sight-seeing in, and excursions from, St. Petersburg. The *Cathedral of St. Isaac*, with gilded dome, the Sanctuary lavishly adorned with malachite and lapis-lazuli; the sumptuous ikonostasis; and the three beautifully decorated bronze doors, which are the largest in the world. The *Nevski Prospekt*, three miles long. The *Admiralty*, with gilded spire.

Second Day. The *Kazan Cathedral*, with magnificent colonnade of four rows of granite pillars, its light and brilliant ikonostasis, and its costly and numerous military votive offerings. The *Gostiny Dvor*, or colossal bazaar. *Stchukin* and *Apraxin Markets*. The *St. Alexander Nevski Monastery*, with massive silver shrine containing the body of the Saint, the bed on which Peter the Great died, and many venerated relics. The *Zoological Garden* should be visited at night for the curious open-air entertainment.

Third Day. On the third day in St. Petersburg, visit the *Winter Palace*. Here, and in the adjoining *Hermitage*, are many of the most valued treasures amassed by various monarchs. The *Cathedral of St. Peter and St. Paul*, with the tombs of all the members of the Imperial family since the foundation of the city, excepting Peter II., who was buried at Moscow. *Peter the Great's Hut* containing the boat known as "the Grandfather of the Russian Navy," and many relics of the great Emperor.

Fourth Day. This would be devoted to an excursion to Peterhof, the Imperial Palace, which is reached either by rail or by steamer down the Neva from St. Petersburg. It is the summer residence of the Imperial family. The rooms are full of objects of extreme value and beauty from all parts of the earth. The gardens are a veritable paradise.

Fifth Day. A trip to Kronstadt, the island fortress, romantically situated on the Gulf. Note Peter the Great's Statue and Summer Garden at the back of the harbour.

Sixth Day. Excursion by steamer to Schlusselburg, at the source of the Neva, on Lake Ladoga.

Seventh Day. The next three days would be devoted to Moscow. The *Kremlin* is the first attraction of this historic city. The wonderful buildings within the Kremlin are the *Cathedral of the Assumption*, where the Tsars are crowned; the *Cathedral of St. Ivan*, with the *Tsar Kolokol*, or largest bell on earth, lying cracked at the foot of the tower; the *Imperial Palace*; the *Cathedral of the Archangel Michael*; the *Cathedral of the Annunciation*, etc.

Eighth Day. The fantastic Church of *St. Basil the Blessed*; the *Great Red Square*; the *Sacred Gate of the Holy Redeemer*; the *Kitai Gorod*, or Chinese City, which is the heart of Moscow and the busiest part, would all claim the tourist's attention. The famous *Romanoff House* could also be seen on the same day.

Ninth Day. This would be taken up with an excursion to the *Sparrow Hills*, whence is obtained the famous view of Moscow; visits to the new and splendid *Church of Our Saviour*; and the *Church of St. Nicholas*.

Tenth Day. Trip to Sergievo, 50 miles from Moscow, by rail. Here is the celebrated ancient monastery of the *Holy Troitsa*, at once one of the most sacred places in Russia and one of the ancient fortresses. Its walls, three miles round, its fortifications, its great convents with 2,000 monks and nuns, its relics and treasures, and its shrine of St. Sergius in one of the five cathedrals within its walls, make it one of the greatest pilgrim resorts of Russia. This place should not be missed by the tourist who desires to see Russian life.

Eleventh Day. Nijni Novgorod. In the latter end of summer, the Great Fair is held here. It is the largest in the world, and is of incomparable interest. The old town, on its amphitheatre of hills, is a place wonderfully situated, at the junction of the grand Volga and Oka Rivers. The old *Kremlin*, with its *Cathedrals*, is of immense antiquity, and full of national associations.

Twelfth Day and Thirteenth Day. Sail down the Volga to Kazan. A delightful river trip, on Europe's grandest stream. The old Tartar City at Kazan is one of the most singular sights of Russia. The tourist will return by night train to Moscow. And thus he has spent a fortnight in Russia, and has gained an excellent acquaintance with one of the world's most interesting lands.

Longer Tours. *Three weeks* in Russia would enable the tourist to see Kieff, the most famous of the holy cities, with its revered shrines, or lavras, and also to visit Tula, the "Birmingham" of Russia, and Yasnaya Polyana, the estate near by belonging to Count Leo

Tolstoy. In addition, a couple of days might be devoted after leaving Russia to the charming capital of Poland. For Warsaw repays a visit as well as any city in Europe.

A *month* would allow the traveller to extend his journey so as to take in a glimpse of the south, seeing Odessa on the Black Sea and the beauty spots on the Crimean Riviera. Livadia, where the Imperial Palace is situated, and Sevastopol may thus be visited.

Travel and Expense. In Russia, so vast is the territory, and so far apart are the chief centres of interest, that much time is necessarily spent in railway travelling or in voyages on the great rivers. But the accommodation is luxurious, alike on the trains and in the magnificent "palace steamers," which resemble those of America. The little "droshky," the national cab, is an exceedingly cheap conveyance, used everywhere in the cities, in which also electric tramways abound. The long journeys should be undertaken by night in the sleeping cars, or on the steamers, as valuable time is thus saved, and Russia is not a land of grand scenery. Its "sights" are its cities, its churches, its palaces, its ancient, vast, and marvellous monasteries, and its curious places of popular entertainment. These afford endless interest, while the phases of native life fill the mind of the observer with constant wonder.

The cost of travel in Russia must be reckoned at about a pound a day. The fare to St. Petersburg from London is, by the Calais-Cologne-Berlin route—1st class, £11 16s. 2d.; return, £18 13s. 4d.; 2nd class, £8 8s. 6d.; return, £13 6s. 11d. But from London or Hull by steamer the charge is only £5 15s., return £9 10s., and the voyage through the Baltic is delightful.

Hotels and Food. The hotels in the large cities of Russia are generally excellent. Nearly all the waiters are young Tartars, who are first-rate servants. Very good restaurants abound. Russia is a land of rich and gross abundance of food. All sorts of peculiar national dishes astonish the visitor from the West. Sterlet and sturgeon are constantly placed on the table, deliciously prepared. The popular soups—"borsht" and "stchi"—are always in evidence. Mushrooms are gathered in enormous quantities, and served up in endless varieties of dishes. The tea is excellent, prepared in the national utensil, the "samovar." It is usually taken with a slice of lemon in it, without milk or sugar. The famous, but deleterious spirit, "vodka," should be shunned, but many varieties of the drink called "kwas" are both delicious and harmless.

Literature. Books on Russia are now numerous. "Russian Rambles," by Miss Hapgood; "Moscow," by Wirt Gerrare; "In Joyful Russia," by J. A. Logan; "Russian Pictures," by T. Mitchell; "Russian Life in Town and Country," by Francis H. E. Palmer; "Out of Doors in Tsarland," by F. Whishaw; Miss Morris's "Summer in Kieff"; and, above all, Wallace's great work in two volumes, entitled "Russia," should all be studied.

GREECE

Year after year the classic realms of Greece are frequented by increasing numbers of tourists impressed by the wish to make acquaintance with the matchless architectural memorials of Hellenic genius. Whether we tread the soil of the Peloponnesus or the Morea, of Achaia or of Argolis, of the Hydra Country which was the land of Hercules, or of Agamemnon's kingdom round Mycenæ, we come alike under the glamour of the world's golden age of poesy and mythology, and we feel the spell of Pericles and Demosthenes in Athens, and of Herodotus and Thucydides in all the magic regions where romantic histories have left their monumental vestiges. A tour in Greece, the "Holy Land of the Ideal," is one of the chief essentials in a complete educational programme of travel. We go to beautiful Hellas to see the memorials of some of the most wonderful "beginnings of history." But apart from its associations with the imperishable heroism of antiquity, modern Greece is replete with unique charms that appeal to every cultured mind. Perennial sunshine, lovely mountain ranges, valleys abounding in flowers and fruits, and a most picturesque people, speaking the melodious tongue directly descended from the diction of Homer and Sophocles, all contribute to the peculiar attractions of the little country fringed by a glorious archipelago.

Many tourists manage to spare a week in Greece on their way further eastward. This shows only a very small fraction of the country, but even so brief a visit is a delightful episode, During a week the Piræus, Athens, Nauplia, Eleusis, Daphne, Corinth, and Patras can be seen, although the glimpse of each of these places will, of course, be hasty. But the round can be accomplished, as the distances are very short and communication is easy.

A Fortnight in Greece. Two weeks afford excellent scope for viewing many of the spots that appeal most powerfully to the interest of the visitor.

First Day. The Piræus is the great harbour commenced by Themistocles. Train journey of half an hour to Athens. Here the visitor is in the midst of a world of wonders. The *Acropolis*, crowned by the white marble *Parthenon*, erected in honour of Minerva. Clustering on and about the Acropolis are the *Temple of Victory*, the *Erectheum*, and the *Propylœa*. The view from the summit is glorious. The *Pnyx Hill*, associated with the eloquence of Demosthenes and Pericles; the *Bema*, whence the orators spoke, intact in its steps to-day; *Mars Hill*, or the Areopagus, with which the name of the Apostle is for ever connected, near by. The *Prison of Socrates*.

Second Day. On the second day in Athens, visit the Temples of *Bacchus* and of *Dionysus*. These are perfect white marble specimens of the open-air theatres of the ancient Hellenes, where the tragedies of Æschylus, the comedies of Aristophanes, etc., were acted. The *Porch of Hadrian*; the *Panathenaic Stadium*; the beautiful *Temple of Theseus*, almost the oldest edifice in Athens, and the most absolutely perfect.

Third Day. The third day in Athens will be devoted to the *House of Dr. Schliemann* (permission being obtained from Madame Schliemann to view the wonderful museum here), the *Hagia Triada*, or Holy Cemetery, unearthed a few years ago, containing the wonderful old Street of Tombs, all with figures in high relief, life size, white marble. The groups are marvellous and most pathetic; the *Royal Gardens*; the *Museum*, containing a magnificent collection of antiquities.

Fourth Day. Excursion to New Phaleron, by light railway. Here a delightful sea-bath may be enjoyed.

Fifth Day. Excursion to Eleusis. Wonderful ruins strew the route along the *Sacred Way* to the scene of the ancient Eleusinian Mysteries. The road goes through the pretty *Pass of Daphne*. Grand view from the top of the Pass. *Monastery of Daphne*. Eleusis, the birthplace of Æschylus. Here are the massive ruins of the *Great Propylæa*, built by Hadrian, of the *Lesser Propylæa*, with the chariot ruts made ages ago, the plateau where stood the great and famous *Temple of the Mysteries*, and the *Chapel of the Panagia*; here, also, is a small *Temple of Artemis*.

Sixth Day. Excursion to Marathon. This can be done by a carriage in a day. From the ridge over which the road passes is obtained a magnificent view of sea, islands, and mountains. The stopping-place is a solitary farmhouse in the middle of the Plain of Marathon; close by is a mound called *Soros*, from the top of which is secured a survey of the whole Battlefield of Marathon, where was settled the fate of Greece. This is the mound erected over the bodies of the Athenians who fell in the momentous fight.

Seventh Day. Corinth. An interesting day may be spent in walking about the town of New Corinth. The little shops, the curious little houses, the ovens in the middle of the streets, and the typical native market, with farmers, peasants, and their wives and daughters in national costumes, are specially attractive to the stranger.

Eighth Day. The village of Old Corinth. The day will be spent, after seeing the wonderful ruins of an ancient *Temple*, and a visit to the *Bath of Aphrodite*, in an excursion to the majestic *Acro-Corinth*. The ascent is not arduous, and the view from the summit is by many considered the most marvellous in Europe. It embraces the snow-clad Parnassus, and the beautiful ranges of Lykabettos, Hymettos, Laurion, Helicon, and Kithairon. In descending, we visit the famous *Fountain of Pirene*, fabled to have gushed forth from the stroke of the hoof of Pegasus.

Ninth Day. This day will be spent in the long carriage drive from Corinth to Mycenæ, Tiryns, and Nauplia. Such a day is scarcely to be rivalled in any tour. The journey takes the traveller amongst the most curious prehistoric cities. At Mycenæ, we are in Agamemnon's land. Here is one of the Cylcopæan cities, another being at Tiryns. The *Treasury of Atreus* and *Agamemnon's Tomb* are among the wonderful relics of the Homeric Age at Mycenæ. Between Mycenæ and Tiryns, the road runs through the Land of the Hydra, the scene of the exploits of Hercules. After seeing the *Cyclopæan Palace* at Tiryns, the tourist arrives in the evening at Nauplia.

Tenth Day. The tenth day affords an enjoyable opportunity of staying at the beautifully situated marine stronghold of Southern Greece, Nauplia. The *Acropolis*, and the *Fortress of Palamid*.

Eleventh Day. By train from Nauplia to Argos. The wonderful ancient Greek *Theatre*, which would hold 20,000 spectators; the lofty *Acropolis* on the Hill of Larissa; grand view from the summit.

Twelfth Day. Train to Kalamata. This is a pleasant port. From this point an excursion is made to the *Ruins of Messene*, the ancient capital of Messinia. Seven of the original thirty grand towers stand in the midst of the splendid remains of the rival to Sparta. On a hill near by, the *Monastery of Vurkano* gives a noble view of the surrounding beautiful district. Note the fine old *Arcadian Gate*; the ancient *Theatre*, an ivied ruin, and the *Stadium*. Return to Kalamata.

Thirteenth Day. Proceed to Megara; a most interesting town of 6,000 inhabitants, with fine remains of the grand ancient town. The *Platia*, on the site of the ancient Agora. At Easter, the famous dances of the season are performed at Megara, and thousands flock to witness them.

Fourteenth Day. Return to Athens.

Longer Tours. *Three weeks* will give the tourist a very excellent extra opportunity of seeing other most desirable points of interest. The third week could be best used for visiting Sparta, Ithome, Taygetus, Olympia, and Patras.

A *month* would enable the traveller to add to his experiences by a supplementary week for a trip through certain classic northern districts, including Delphi, the region round Parnassus, Orchomenos, Thermopylæ, Thebes, and Platæa.

Travel and Expense. The pleasures of travelling in Greece are enhanced by the peculiar conditions of daily life. The people commonly drink wine called "resinata," because it is strongly flavoured with resin, as they imagine this is beneficial to their health. Very little butter is eaten. Fruit is very plentiful. The cost of travelling is somewhat high, for much of it must be done by carriage driving, and a guide is necessary everywhere. The expense should not be reckoned at less than 30s. a day on the average. A 1st class ticket from London to Athens by the cheapest route costs £14 19s. 4d; 2nd class, £10 8s. 8d.

Language. The pleasure of a visit to Greece is immensely enhanced by a little acquaintance with the language. Anyone who is a scholar in ancient Greek can in a very few weeks acquire an elementary knowledge of Romaic, or modern Greek, for this is wonderfully similar to the primitive classic language. The natives are specially pleased to give attention to those who have taken the trouble to make some acquaintance with their beautiful dialect.

Literature. Books on modern Greece are abundant. Amongst the best for the intending traveller are Diehl's "Excursions in Greece," Lord Carnarvon's "Athens and Morea," Agnes Smith's "Greek Life and Scenery," Barrow's "Isles and Shrines of Greece," Armstrong's "Two Englishwomen in Greece," Tuckerman's "Greeks of To-day," Jebb's "Modern Greece," and Millar's "Greek Life."

Continued

CHOICE AND USE OF A TYPEWRITER

The Working Principles of the Various Machines. Care of Machine. The Standard Keyboard. Touch. Fingering

Group 27

TYPEWRITING

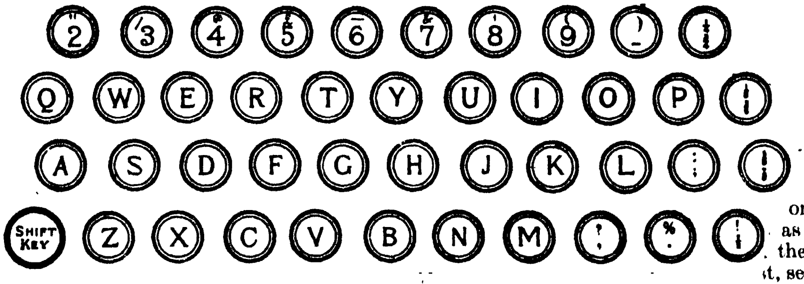
1

By MARGARET LILLIE

IN this course it is intended to deal with the business of typewriting in such a way that the student may be enabled to apply the general principles set out to any particular machine he wishes to use.

There is great similarity in the construction of typewriters, and a general knowledge of the fundamental principles of one machine will, to a large extent, apply to all makes.

The Mechanism. In the first place it is necessary to understand something of the process which goes on from the time the key is depressed to the actual impression as we see it on the paper. There is nothing very complicated in a typewriter, but sometimes the simplest misplacement of a part will make good work a sheer impossibility; and as it is not always convenient to wait for help, a little trouble in the beginning is its own reward.



THE "STANDARD" KEYBOARD

From each key a lever projects horizontally to the rear. From the middle of this rises a connecting rod, at the end of which is a type bar, corresponding with the letter on the key. This key-lever is pivoted, so that when the key is depressed, the type bar approaches the printing point, and the type at its end strikes the ribbon, leaving an impression on the paper. Obviously another movement is now necessary to prevent the next letter striking the paper in the same place. This is effected automatically in this way. Under all the key-levers is a horizontal bar, extending from side to side in the machine, so that when a key is depressed, the bar also is depressed. The latter pulls down its connecting rods, and they in turn rock an escapement, the most important feature of which is the *dogs*, one of which is loose, and the other rigid. These dogs, when they rock, allow the carriage to move the width of one letter, so that at each step the type prints at a different point. The force necessary to pull the carriage along is supplied by a mainspring, which is automatically wound up every time the carriage is pulled to the right. The movement, step by step from right to left, is governed by the action of the dogs as already described.

The art of typewriting is so apparently easy that pupils are apt to underestimate the difficulties which await them; and this is the cause of much of the unsatisfactory workmanship of which business men so frequently complain. Too little time is given to study, and the result is work which can give satisfaction neither to the typist nor to the person for whom it is done. There can be little pleasure for the operator who has to turn out a considerable amount of work a day if that work, through incompetency, is irksome. Whatever difficulties have to be overcome are very materially minimised if the typist is master of the machine; and the effect of a batch of beautiful, regular manuscript is ample
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Continued from
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PROVISIONS IN SEASON

Rules for Making Stock, Milk Puddings, Pastry, Batters and Cakes. Table of Provisions for Each Month of the Year

RULES FOR MAKING STOCK FROM FRESH MEAT

1. Use good fresh ingredients, and see that the pot is clean.
2. With one quart of cold water use one pound of raw meat and bones.
3. Chop the bones small, cut the meat into small pieces, and let these soak a little in cold water before cooking.
4. Leave the vegetables whole, after cleaning them, or merely cut them in halves. Add them when the stock has boiled and been skimmed.
5. Take out the vegetables when they are tender, as by then their flavour will have been extracted, and they will then *absorb* the flavour.
6. Bring the stock slowly to the boiling point.
7. Simmer it steadily, unless much bone is used or gristly portions, when it must boil more quickly to soften the gelatinous matter. Gelatinous stock is very digestible, but contains less flavour and nutriment than if made from lean meat.

RULES FOR BAKING MILK PUDDINGS

1. Use barely two ounces of rice, sago, tapioca, semolina, etc., to each pint of milk ; otherwise, if more be taken, the starch grains, which swell to about three times their original size, have not room to swell.
2. Cook milk puddings very slowly, so that the starch grains have time to soften, swell, burst, and thicken the milk, making it rich and creamy before the latter is wasted by evaporation.
3. If eggs are added, specially slow cooking is needed, and the mixture should be cooked before the beaten egg is added, or it will curdle.
4. Small grains and powders, such as semolina, small sago, cornflour, etc., should be boiled first in the milk before being put in the dish or they cook unevenly.

RULES FOR REHEATING COLD MEAT

1. Cut off all bones and rough pieces, put them into a pan with enough cold water to cover them, add a little salt, onion and parsley, and boil them down for stock.
2. Always use this stock for gravy, never water, or the dish is weak and insipid.
3. Do not put the meat into *cold* gravy, or the juices will be extracted and the meat rendered tasteless ; nor yet into *boiling* gravy, or it will be instantly hardened and made tough.
4. Carefully fry the flour used for thickening, so that the gravy is not too pale or dark ; also see that it is of a good consistency—not watery, nor yet like porridge.
5. Remember the meat has already lost some of its flavour in the first cooking, so somewhat high seasoning is required.
6. Also the meat is already cooked, so it must only be *reheated*, on no account *recooked*, not even gently simmered.
7. Let the meat of curries, hash, etc., remain in the gravy long enough to be well flavoured by it.
8. Where meat is to be exposed to great heat, either by frying or baking, protect it by a covering of egg and crumbs, potato or batter, etc.

RULES FOR MAKING PASTRY

1. Make it in a cold place if possible.
2. Keep hands, utensils, and ingredients as cool as possible, or the pastry becomes heavy.
3. Rub in the shortening lightly with the tips of the fingers, as they are the coolest part of the hand.
4. Add the water carefully, so as to avoid making the pastry either too dry or moist. If the former, it will be hard and chippy ; if the latter, heavy and sodden.
5. Handle pastry as little and as lightly as possible.
6. Use the rolling-pin lightly, and with even pressure.
7. If baking powder is used, bake the pastry as soon as possible after adding the moisture, or the carbonic acid gas thrown off the baking powder, when moistened, will have forced its way out of the paste, and the effect of its action will be lost.
8. Bake pastry in a very hot oven, to expand the air in it and thus lift up and lighten the flour.

RULES FOR BATTERS

1. As the name indicates, all these mixtures must be thoroughly and correctly beaten, in order to introduce air into them, for, as this air forces its way out of the batter and expands with heat, it raises it, making it light.
2. Eggs and milk must be stirred in gradually and smoothly, or lumps will be formed.
3. Never add more than half the liquid before beating, or it will be so thin that it will splash; also it cannot, for the same reason, form a sufficiently strong film round the air bubbles to retain the air which will be beaten out again with the next blow of the spoon.
4. After all the liquid is added, batters should stand if possible, because starch grains soften and swell in cold liquids, thus rendering their cooking more quickly and more easily performed.
5. All batters become tough speedily as they cool, and therefore must be served immediately.

RULES FOR CAKE MAKING

1. Use good ingredients, dry flour, clean fruit.
2. Beat eggs, butter, and sugar well to lighten the cakes *before* the flour is added—not afterwards, or the cakes will be heavy.

TABLE OF PROVISIONS FOR EACH MONTH OF THE YEAR

Meat.	Fish.	Poultry.	Game.	Vegetables.	Fruit.
January					
Beef Mutton Pork Veal	Brill, Cod, Dory Haddocks, Flounders Eels, Mackerel Herrings, Soles, Mullet Turbot, Smelts, Sprats Whiting, Plaice Whitebait, Oysters Lobsters, Prawns	Turkeys Fowls Geese Pigeons Rabbits	Partridges Venison Wild Duck Quails Widgeon Pheasant Snipe	Artichokes Brussels Sprouts Cabbages, Carrots Celery, Cauliflowers Leeks, Onions Parsnips, Spinach Turnips, Seakale Tomatoes, Salsify Swedes	Apples, Oranges Nuts, Pears, Grapes Bananas Forced Rhubarb Pineapples Italian Figs
February					
Beef Mutton Veal Pork	Brill, Cod, Cockles Crabs, Flounders, Eels Haddocks, Halibut Hake, Herrings Lobsters, Mackerel Mullet, Mussels Oysters, Pike, Perch Plaice, Prawns, Salmon Shrimps, Soles, Sprats Tench, Turbot Lemon Soles, Whiting Crayfish	Capons Chickens Ducks Geese Rabbits Turkeys Guinea Fowls	Hares Partridges Pheasants Plovers Snipe Woodcock	Beetroot, Broccoli Cabbages, Carrots Celery, Celeriac, Leeks Lettuces, Onions Mushrooms, Parsnips Salsify, Seakale, Sorrel Sprouts, Turnips Shallots	Apples, Oranges Nuts of all kinds Winter Pears Forced Rhubarb Pines
March					
Beef Veal Mutton Pork Lamb	Dory, Eels, Flounders Mackerel, Haddocks Scallops, Shrimps Sprats, Trout, Turbot Smelts, Lobsters Oysters, Crawfish Crayfish, Whitebait	Chickens Ducks Geese Fowls	Black Game Wild Duck Capercailzie Hares, Teal Widgeon Woodcock Ptarmigan, Quails	Artichokes, Asparagus Beetroot, Cucumbers Shallots, Leeks, Kale New Potatoes (from Jersey) Salsify, Spinach Tomatoes, Mushrooms	Apples, Oranges Pears, Bananas Grapes, Cape Fruit Forced Rhubarb Russian Cranberries Seville Oranges
April					
Beef Mutton Pork Veal Lamb	Whitebait, Turbot Trout, Smelts, Shrimps Salmon, Scallops Oysters, Crab, Cod Mackerel, Haddocks Flounders, Gurnet Halibut	Chickens Fowls Ducks Ducklings Guinea Fowls Rabbits	Ptarmigan Quails Wild Geese Wild Duck Black Game Prairie Hens	Artichokes, Beetroot Cucumber, Carrots Chervil, Seakale Lettuces, Leeks Onions, Parsnips Salsify, Spinach Asparagus Savoys, Tomatoes Turnips, Mushrooms	Apples, Bananas Oranges, Grapes Pears, Lemons Limes, Rhubarb Grape Fruit Cranberries
May					
Beef Mutton Lamb Pork Veal	Brill, Crabs, Eels Dory, Gurnet Halibut, Lobsters Herrings, Mackerel Plaice, Prawns, Soles Salmon, Trout, Whiting Whitebait, Smelts	Chickens Ducklings Rabbits Guinea Fowls	Leverets Quails Plovers' Eggs	Artichokes, Asparagus Beetroot, Carrots Cucumbers, Leeks Lettuces, Spinach Turnips, Corn Salad Radishes, Onions Tomatoes New Potatoes	Apples, Bananas Grapes, Gooseberries Rhubarb Oranges, Pineapples Forced Strawberries Currants
June					
Beef Mutton Lamb Veal	Brill, Haddocks, Carp Gurnet, Halibut Mackerel, Plaice Salmon, Soles, Shrimps Turbot, Trout Whiting, Whitebait Crabs, Prawns	Chickens Capons Ducks Goslings Turkey poults Rabbits	Hares Quails Venison Plovers' Eggs	Asparagus, Beetroot Carrots, Cucumbers Cabbage Lettuces Leeks, Spinach, Peas Radishes, Mushrooms French Beans Mustard and Cress Salads	Cooking Apricots Bananas, Cherries Currants of all kinds Figs, Raspberries Gooseberries Oranges Strawberries, Limes
July					
Beef Mutton Lamb Veal	Carp, Flounders Gurnet, Haddocks Dory, Herrings, Pike Red and Grey Mullet Turbot, Shrimps Skate, Whiting Whitebait Scotch Salmon Mackerel, Plaice, Soles Lobsters	Chickens Ducks Pigeons Rabbits Turkey poults	Plovers' Eggs Quails Leverets	French, Kidney, and Broad Beans Cauliflowers, Carrots Peas, Potatoes Radishes, Chervil Scarlet Runners Tomatoes, Spinach Sorrel, Salsify, Turnips Marrows, Salads Asparagus, Cos Lettuce Mushrooms, Potatoes Cucumbers, Endive	Apricots, Cherries Currants of all kinds Gooseberries, Melons Nectarines, Peaches Raspberries, Figs Strawberries, Grapes Cape Fruit Pineapples

TABLE OF PROVISIONS FOR EACH MONTH OF THE YEAR—Continued

Meat.	Fish.	Poultry.	Game.	Vegetables.	Fruit.
			August		
Beef Mutton Veal Lamb	Brill, Carp, Cod, Crabs Dory, Eels, Flounders Gurnet, Haddocks Halibut, Herrings Lobsters, Mackerel Mullet, Plaice, Perch Prawns, Salmon Shrimps, Soles, Tench Turbot, Whiting	Chickens Ducks Fowls Pigeons Rabbits Green Geese	Grouse Leverets Plovers Wild Duck Blackcock	Artichokes, Beans Carrots, Celery Cauliflowers, Leeks Mushrooms, Salsify Salads of all kinds Spinach, Turnips Scarlet Runners Marrows, Endive	Apples, Cherries Currants, Damsons Figs, Gooseberries Lemons, Grapes Mulberries, Peaches Pears, Raspberries Plums, Pineapples
			September		
Lamb Veal Beef Mutton	Brill, Crabs, Cod Dory, Eel, Flounders Gurnet, Haddocks Herrings, Halibut Lobster, Mackerel Mullet, Oysters, Plaice Prawns, Soles, Shrimps Skate, Turbot Whiting	Chickens Ducks, Fowls Green Geese Turkeys Pigeons	Grouse Hares Leverets Partridges Plovers Teal Black Game Widgeon Woodcock	Brussels Sprouts, Beans Cabbages, Carrots Leeks, Cauliflowers Celery, Lettuces Mushrooms Horseradish, Onions Jerusalem and Globe Artichokes Parsnips, Peas Radishes, Salad Shallots, Tomatoes Turnips	Apples, Cherries Damsons, Bananas Blackberries, Figs Grapes, Nuts Medlars, Peaches Pears, Plums Quinces, Walnuts Nectarines
			October		
Beef Mutton Veal Pork	Brill, Bass, Cod Crabs, Dory, Eels Flounders, Haddocks Herrings, Halibut Lobster, Mullet, Plaice Oysters, Smelts, Soles Whiting, Turbot	Green Geese Chickens Ducks Pigeons Rabbits Turkeys	Grouse, Hares Moor Game Partridges Pheasants Plovers, Snipe Teal, Widgeon Woodcock Wild Duck	Artichokes, Broccoli Cabbages, Cardoons Cauliflowers, Celery Leeks, Onions Parsnips, Radishes Peas, Potatoes Tomatoes, Turnips Spinach, Savoys Shallots, Salads	Almonds, Apples Bullaces, Damsons Figs, Hazel Nuts Mulberries, Peaches Pears, Quinces Blackberries Walnuts Cranberries, Sloes Chestnuts
			November		
Beef Mutton Pork Veal	Brill, Carp, Cod Cockles, Dory, Eels Flounders, Herrings Halibut, Haddocks Red and Grey Mullet Plaice, Perch, Pike Soles, Scallops, Smelts Skate, Shrimps, Turbot Tench, Whiting Oysters	Capons Chickens Ducks Fowls Geese Rabbits	Grouse Hares Pheasants Partridges Ptarmigan Snipe Teal Widgeon Woodcock Plovers	Artichokes, Beetroot Brussels Sprouts Carrots, Celery Cauliflowers, Cucumbers Greens, Garlic Potatoes, Parsnips Savoys, Spinach Tomatoes, Turnips Leeks Spanish, Pickling, and Cooking Onions French Beans	Apples, Bullaces Chestnuts, Grapes Lemons, Melons Oranges, Pines Pears, Quinces Walnuts, Nuts
			December		
Beef Mutton Pork Veal	Brill, Carp, Cod, Dace Dory, Eels, Flounders Gurnet, Haddocks Halibut, Herrings Ling, Lobsters, Mussels Mackerel, Oysters Perch, Pike, Soles Scallops, Smelts Shrimps, Tench Turbot, Whiting	Chickens Fowls Ducks Geese Rabbits Turkeys	Wild Duck Capercailzie Pintail Duck Wild Geese Grouse (till 10th) Woodcock, Teal Widgeon, Snipe Ptarmigan Venison Grey and Golden Plovers	Brussels Sprouts Artichokes, Celery Beetroot, Cucumbers Greens, Horseradish Kale, Lettuces Parsnips, Shallots Savoys, Salsify Spinach, Tomatoes Chervil	Nuts of all kinds Bananas, Apples Grapes, Lemons Oranges, Tangerines Forced Rhubarb Dates, Figs, Melons

3. Always mix in the flour before the fruit.

4. Line cake-tins with layers of greased paper, to protect the cakes from burning.

5. Bake large cakes slowly, or they will be burnt on the outside before being cooked inside.

6. Bake small cakes quickly, or they become dry and hard—especially if they are not supported by tins, as then, unless it is set quickly, the mixture spreads flat out on the tin.

7. To know if cakes are cooked enough, push a skewer through the thickest part, and see if it is quite bright and clean on being pulled out. If so, they are cooked ; but not if the skewer appears greasy or has some soft mixture sticking to it.

Continued

LIGHT AND SHADE

Mediums. Important Principles. Lighting the Group. Keys, Divisions, and Perception of Light and Shade. Drawing with Chalk and Stumps

Continued from page 1414

By WILLIAM R. COPE

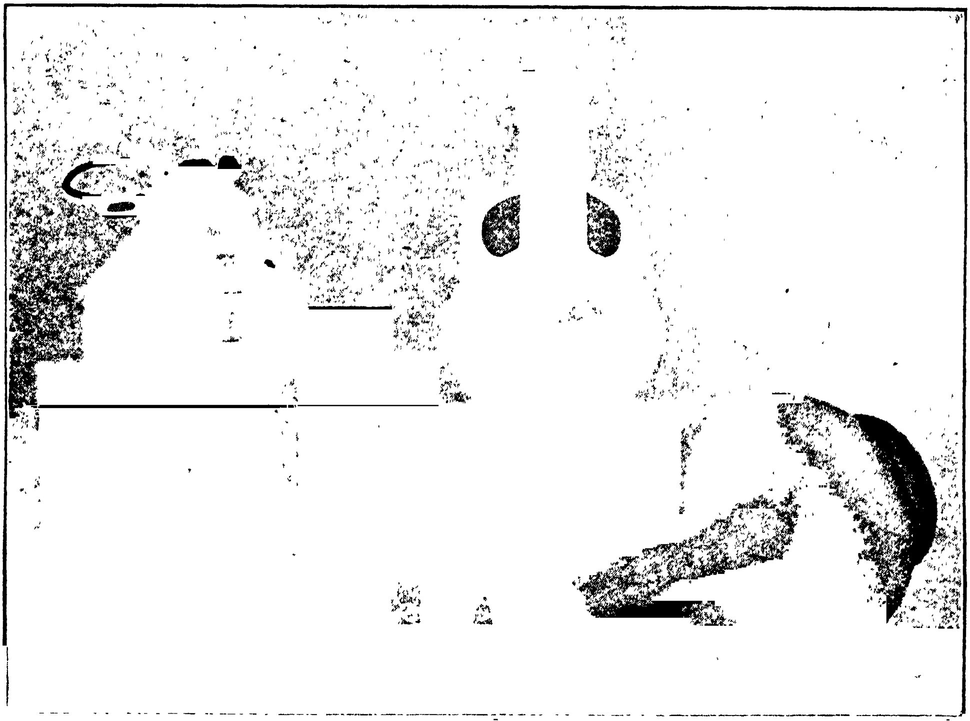
THOSE students who have mastered the principles of object drawing should now attempt to shade the drawings; but it must be distinctly borne in mind that *correct* drawing, as regards proportion and perspective, must be accomplished first, for the most careful and finest shading in any medium will never hide bad drawing; rather, it will emphasise it.

Different Methods of Shading. There are many mediums in use for shading, and each has its own advantages and disadvantages. The most commonly used mediums are:

1. POWDERED CHALK AND STUMPS. The great advantages of this medium are that errors may be easily rectified, and work may be left off at any moment. The disadvantage is that it is a medium rarely used outside a school of art, and when doing more advanced work, as drawing from life. Yet, on the whole, it is a very convenient medium in which to work and obtain a good training in the principles of the light and shade of any object, and excellent results are certainly obtained thereby. 396 and 397 are taken from drawings made entirely with the stumps and chalk. The originals were much larger than the illustrations here given, being executed on paper 30 in. by 20 in. in size.

2. WASHES OF WATER COLOUR (*Sepia or liquid Indian ink*). This is undoubtedly a very good medium to use, but as errors are not very easily rectified, most careful observation of the object, as regards its tone values, etc., must be made in order to have in the brain a definite idea of what is wanted before making a wash on the drawing paper. This is really a very good training for a beginner, as he is compelled to observe in a most searching manner before doing a stroke of his drawing or painting, unless he wishes to get a result which has no freshness or life in it, but is all blotches, smudges, ragged and woolly edges, with the good drawing practically spoilt or lost altogether.

3. LEAD PENCIL. Although this is a very convenient medium, and work may be left off at any



396. STUMPING CHALK DRAWING OF A GROUP OF OBJECTS

moment, yet errors are not so easily rectified as when using stumping chalk, for the pencil lines are apt to be smeared, and thus leave a greasy appearance when rubbed with the indiarubber. There is also the objection of "shine." Most beginners have not that *light* and *certain* touch which is required to obtain satisfactory results with the pencil. Yet a few lines of shading properly put in quickly give the appearance of roundness or solidity to an outline drawing.

4. ACADEMY CHALK. This has not the objection of "shine," but, like the lead pencil, requires a delicate and certain touch to obtain really good results. It is a very good medium for those students who know exactly what value of tone is wanted before they put it down on paper, which, of course, means the student must have had a good training in judging tone values before he can use academy chalk successfully.

5. CHARCOAL. This is a medium very much used in drawing from the antique or from the living model, and often by beginners in shading from simple objects, or from a cast of an ornament. Errors may be very easily corrected, as the charcoal rubs off more easily than any other medium; but when the drawing is completed it may be "fixed" by spraying on it some shellac or gum arabic dissolved in spirits of wine. Charcoal is sometimes used with white chalk for drawing on coloured paper; brown paper will do admirably, its colour being utilised for the half tones, the charcoal for the shadows and shades, and the white chalk for the high lights and lighter tones of the drawing.

6. PEN-AND-INK. This medium is for advanced students, as considerable knowledge in drawing and shading is required before pen-and-ink work can be satisfactorily accomplished.

Principles of Light and Shade. The student must remember that he is now to represent objects, not by outline alone, but by means of light and shade; and that, although he makes a preliminary sketch in pencil, *the outline must not appear in the finished shaded drawing*, as there are no *outlines* in Nature, only edges, which are sometimes visible as light against dark, or vice versâ. Often the edges are lost in shade, or it may be that two adjoining surfaces are of exactly the same tone, and so the edge is invisible. Beginners often make great mistakes about edges, because, knowing they are really there in the objects, they feel that they must be put in; but students must remember the rule: "Draw what you see." It will be found that a better sense of atmosphere and relief will be shown if the edges are lost, softened, or sharpened in their proper places.

Tones Impossible to Represent. There are so many various values of lights and darks in the objects around us that at first the student may be bewildered, and not know what to do. Sometimes the contrast between the "highest," or brightest light, and the "lowest," or darkest dark tone is so great that, although we may be able with black chalk to obtain a tone as dark as the darkest shadow, it is impossible to represent the brilliant light with the means at our disposal, for neither white paper nor white paint is bright enough. For example, it is impossible to represent accurately some brilliant artificial light, and artists often overcome this difficulty by placing a small screen or shade in front of the brilliant light; then, although a good deal of light is seen around the screen, yet the *value in tone* of the visible light is not so bright compared with the darker tones, and can be more truthfully represented.

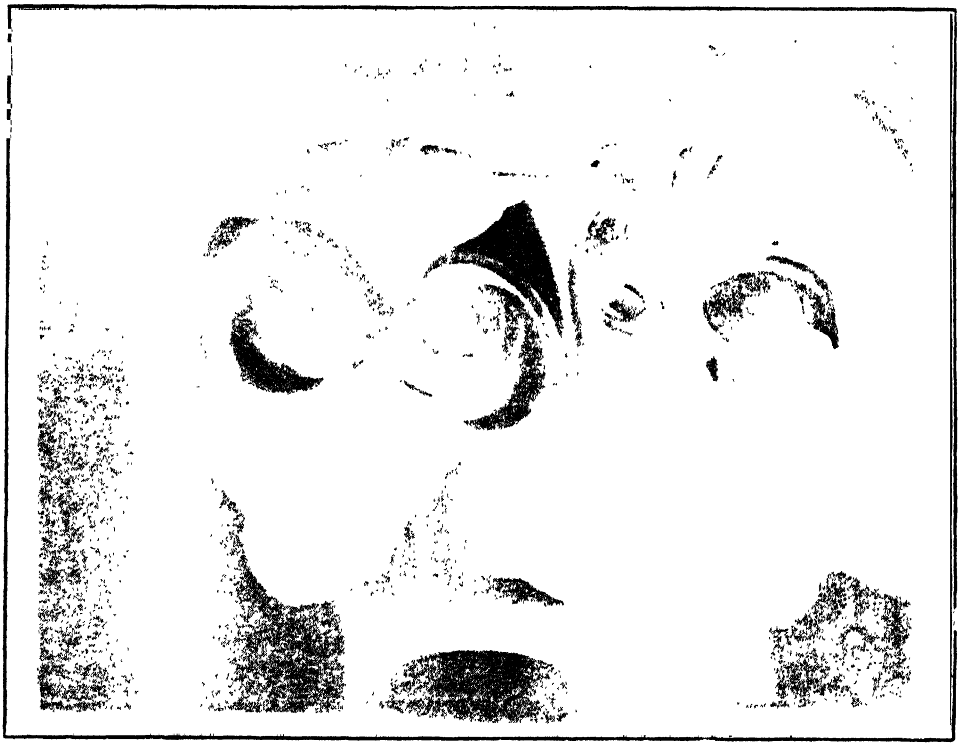
Lighting the Group. The preceding is, of course, an extreme example, and in ordinary cases we do not get such marked difference between "high" light and darkest shadow. The student should take considerable pains in arranging for the "lighting" of the object or objects he is studying. The light should come, preferably, from the left-hand side of the student, so that it slants down at an angle of about 45 degrees; care must also be taken to obtain a harmonious balance of light and shade. With artificial light it is difficult to avoid hard, sharp-edged shadows, which rarely, if ever, have an artistic effect; but if a shade of "frosted" glass be placed over the light a more diffused illumination will be obtained, and will cause the edges of the shadows to be softer. If the objects are lighted by daylight, avoid letting the direct rays of the sun shine on the group, for the light and shade would change every minute, as the sun appears to move, and, also, the shadows would be sharp and hard. The best light is diffused daylight.

Different "Keys" of Light and Shade. A drawing may be made in any "key" of light and shade. For example, a silver point drawing is in a much lighter or higher key of tone than a study executed in Conté crayon, charcoal, sepia, or stumping chalk, which may be in a medium, or even a very dark or "low" key of tone, and yet there is an excellent representation of roundness or relief in the silver point drawing as in the others. Nevertheless, a beginner should not trouble about such transpositions of the key of tone, but should endeavour to represent as truthfully and accurately as he can the apparent values of the light and shade of the objects of study in *the same key as they appear*.

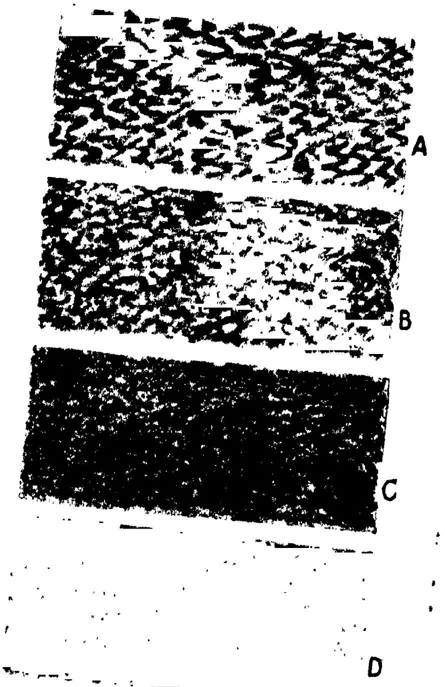
Divisions of Light and Shade. Light and shade may be divided into five main divisions, as follows: (1) *Light*, the part of the object upon which the light directly falls; (2) *shade*, the part of the object, turned away from the light, and, therefore, more or less dark in tone; (3) *shadow*, which is the dark portion of surrounding surfaces, and is produced by the object intervening between the source of light and the surfaces, forming a "*cast shadow*," as it is called; (4) *half-tone*, the part of the object's surface which is between the "light" and "shade" portions; (5) *reflected light*, which is in some part of the "shade" surface, and is caused by the reflection of light from some other portion of the same or another object. Each of the above five divisions may be subdivided into very many various degrees of light, shade, shadow, etc., for, although one part may be light, it will rarely be of the same degree of light throughout that light part, and so with the "shade," "shadow," "half-tone," or "reflected light" parts, there will usually be varying degrees of each.

Training the Eye to See Light and Shade. The student will therefore see that he has to make much careful observation and comparison before he will *see* the correct appearance of the values of the different tones. It is best to determine first the darkest "dark" and the highest or lightest "light," then it will be easier to judge all other values between these two extremes. The student's work will now be more interesting than when drawing in simple outline; he will have further means by which he can give a truer and more lifelike representation of objects or views around him; and his perceptive faculties will be put to still further severe tests of their powers of judging accurately. There must be continual and intelligent comparison between one part and *the whole*, to find out the relative values of tones, edges, etc. It is a capital plan to place the drawing beside the objects of study, then sit in the same place from which they are being viewed and drawn, and make careful, searching comparison between the drawing and the group. The student will be surprised how easily he will detect errors in judgment of tone values, etc., and perhaps he will ask himself why he could not see these mistakes, or why he made them at all when working on the drawing in its usual place on the easel. The reason generally is that he has looked at each part too individually, and when the drawing is at a distance, he is compelled to look at it *as a whole*. Thus, if he has an observant and critical eye, he cannot fail to see discrepancies in his work. Yet, however critical he may be, there are sure to be errors which he cannot find by himself, owing to his lack of training, and therefore he should obtain, as often as possible, the criticism of some artist friend who has had considerable experience.

Shading with Chalk and Stumps. A box of shading materials, containing all that is necessary, may be obtained of any artists' colourman. Some chalk is spread on the chamois leather palette, or on a piece of paper, being rubbed on lightly, so that no loose particles are about; and the stump is rolled around in the chalk on the palette, so that about half or three-quarters of an inch of the pointed end is evenly charged with the chalk. Three stumps should be used—one for the darkest tones, one for the medium, and another, with scarcely any chalk on it, for the lightest tones. Always use the largest stump possible for convenience, so as to avoid a niggling style of work. *Do not rub hard*, or the work will appear dull and leaden, with no life or sparkle in it, as the pores of the drawing paper (which should be Whatman's or O. W. S., *not* surface) should not be



397. STUMPING CHALK DRAWING FROM A CAST OF AN EARLY ENGLISH CAPITAL



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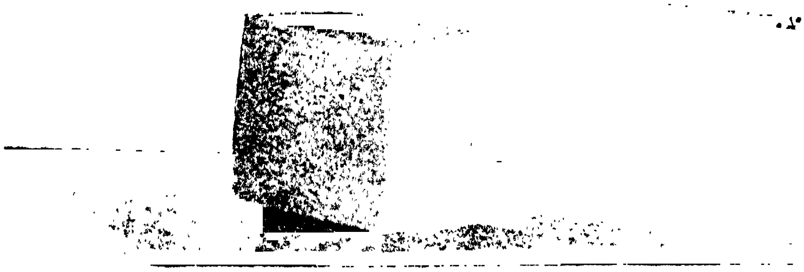

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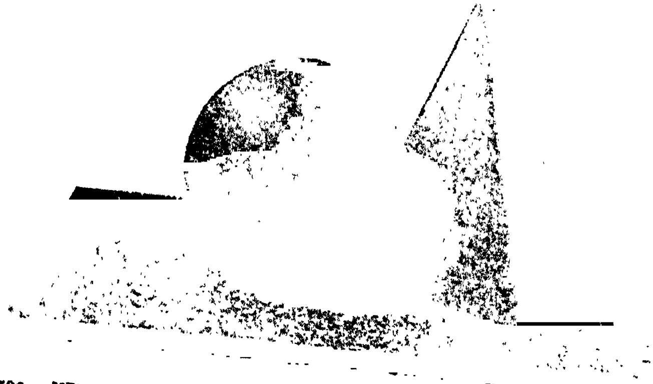
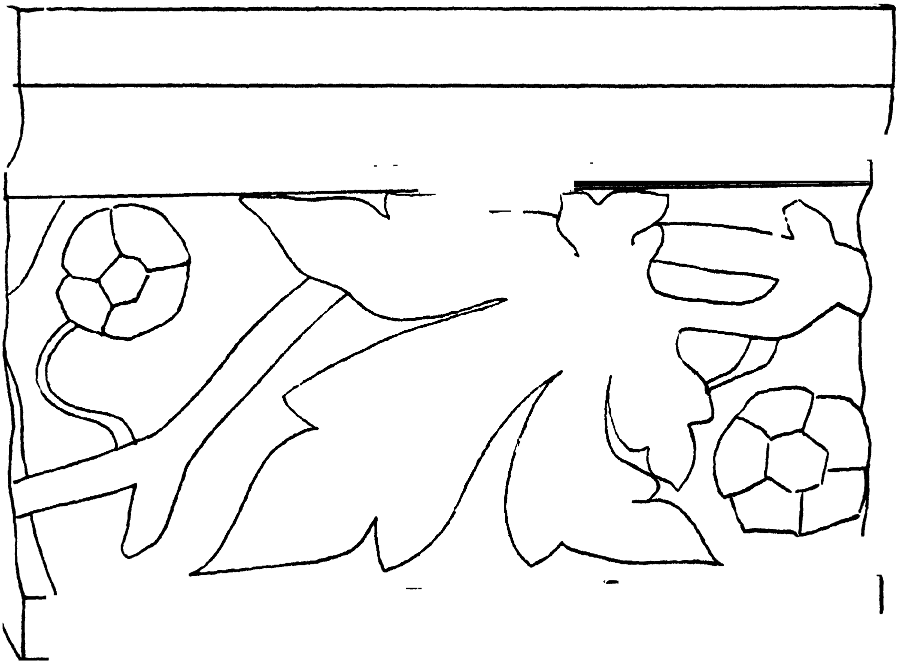


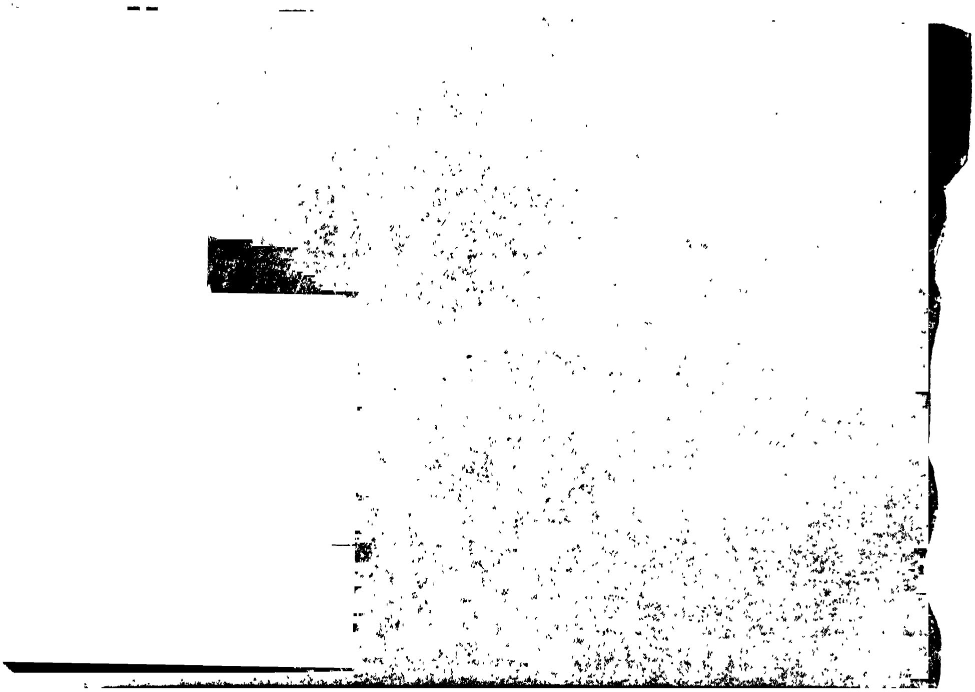
choked with chalk; but even in the darkest shadows there should be an appearance of little points of light showing through the dark chalk. Many students rub hard because, they say, they cannot make the tone dark enough without doing so, forgetting that it really is because they have not sufficient chalk on the stump, which should be freshly charged very often when a dark tone is required. A piece of sharp-pointed rubber should be used to pick out the too dark spots or blotches, which will almost inevitably come where they are not wanted. Again, do not grip the stump as if it were a broomstick or a crowbar, but hold it lightly, yet firmly, between finger and thumb, so that the angle it makes with the drawing paper may be varied as occasion requires. The *side* of the stump should be used chiefly, and the point only when working in corners or confined spaces, or for certain kinds of sharp edges.

There are several methods of putting the chalk on the drawing paper, but perhaps the best is that shown in **398**, A, B, C, and D, where in A each wavy stroke is placed close to the others in such a way that there is a general evenness of tone, although each stroke shows up rather distinctly and the work is somewhat coarse and open. The light places should then be gone over with the stump properly charged with chalk, so as to obtain the appearance in **398B**. Then, with further use of the stump to fill in lighter places, and, if necessary, the rubber to pick out the dark blotches, produce a more even tone, as in **398C**. Last of all, finish with stump and rubber to obtain a tone like **398D**. Beginners should draw a square, about 3 in. square, and endeavour to make an even tone (like **398D**) to fill it, in order to get accustomed to the use of the stump. When this is satisfactorily accomplished, draw an oblong, about 6 × 3 in., and fill it with a graduated tone, as in **399**. Begin with the lightest tone at the top, and gradually increase the depth or darkness of the tone. There should be no sudden change from one tone to the next in this exercise, and no blotches, but an effect like **399**.

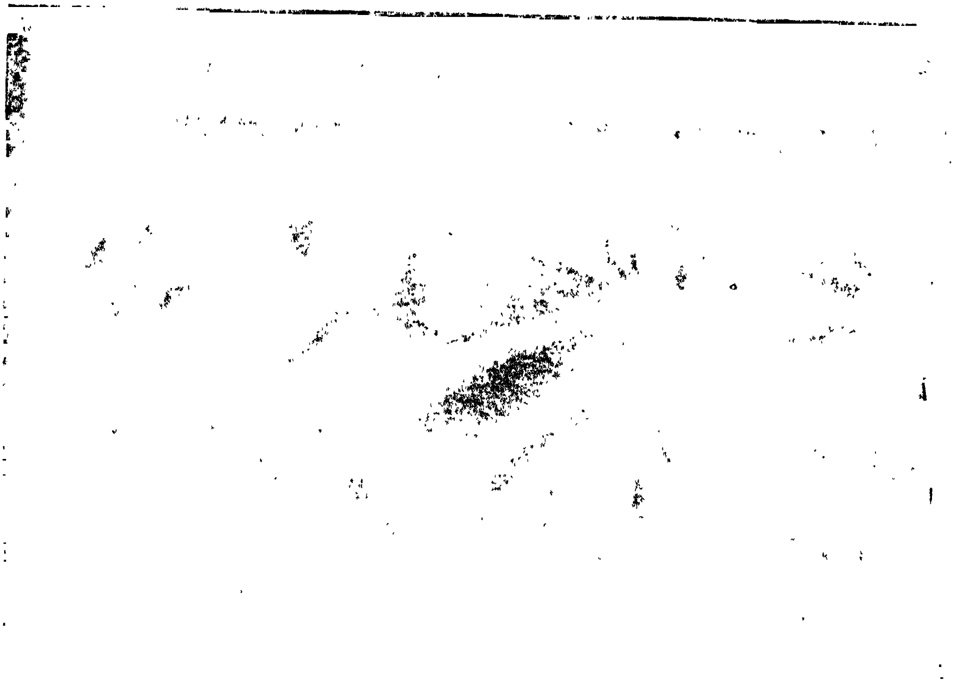
Simple Groups. Having mastered the technical difficulties of using the chalk, stumps, and rubber for obtaining an even as well as a graduated tone, proceed to study some simple group as shown in **400**. The objects should be white or very light in colour, so that the student is not worried yet with colour values. Arrange the lighting of the group carefully, and place a large piece of white paper or cardboard vertically and about a foot behind the group, as, for the present, it is best to work without putting in the background; thus the white paper behind will help when judging the tone values of the objects in the group. Make a sketch, lightly drawn in lead pencil, not only of the objects, but also of the shapes of the shadows, and nearly rub out the pencil lines. Spend some four or five minutes in careful observation of the group—as regards its darkest and lightest tones, the different values of light and shade in the same or other surfaces, the changing value



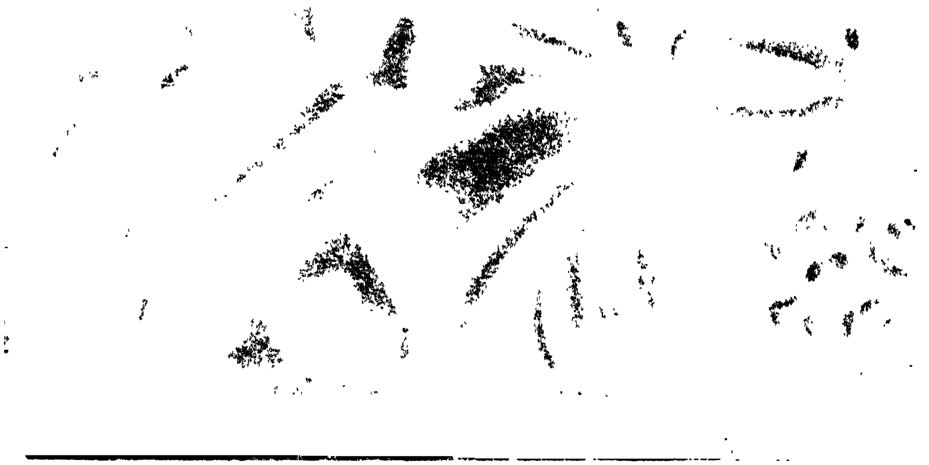
402. STAGE I. OUTLINE SKETCH FOR SHADING WITH STUMPING CHALK



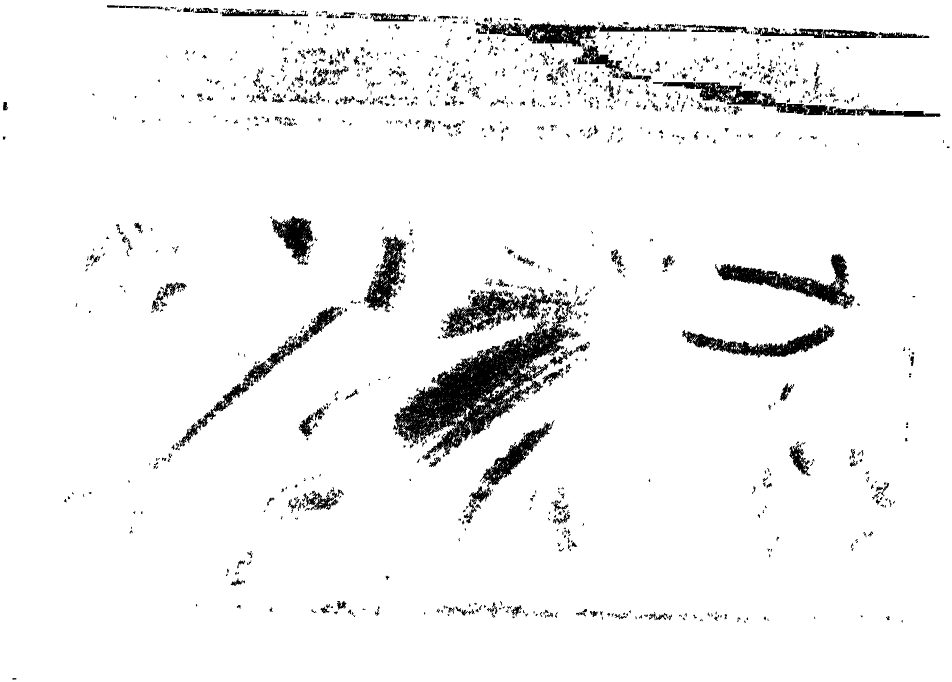
403. STAGE II. EVEN TONE OF SHADING WITH STUMPING CHALK



404. STAGE III. CHIEF LIGHT SHADES TAKEN OUT WITH INDIARUBBER



405. STAGE IV. MAIN SHADOWS AND SHADES ADDED TO CHIEF LIGHTS



406. STAGE V. FINISHED DRAWING WITH STUMPING CHALK

of the edge of the cast shadow, which is sharp where it is close to the edge of the object which produces the shadow, and gradually becomes softer the further the shadow's edge is from that part of the object which causes the shadow. There may be reflected light in some shade surfaces, as in one face of the cube, and it must be particularly noticed that, although a plane surface may be equally lighted from diffused daylight or any other light, the whole surface of the plane will not necessarily appear to be of the same value of tone, but may seem lighter in one part than in another, as in the drawing-board and the three surfaces of the cube. These preliminary and searching observations will save many errors and much vexation.

Shading. Now proceed to shade the darkest surface and cast shadow of the cube. Dark tones should generally be put in first, as their true value is more easily judged than that of light ones. Next put in the medium, and afterwards the lighter tones, noting all the time their relative values and darkest tones. Pay attention to the value of edges both of the objects and of the cast shadow. Then place the drawing beside the group, and make a searching criticism, correct all errors, and put more " finish " in the texture of the shading, although "finish," as regards stippling, is not to take the place of, nor is it so important as, the *true values* of tones, edges, etc. Nevertheless, a certain amount of "finish" is required to represent satisfactorily the smooth texture of some kinds of materials. The student must use his judgment in this matter. Do not forget that *drawing* must enter into every part of shading, for the former is not finished when the sketch in pencil is made.

A more difficult group, as shown in **401**, may now be attempted. Here " rounded " or curved surfaces are to be represented, but, keeping in mind the previous advice about observation of tone values, etc., no great difficulty should be found. Do not make the reflected light too bright on the lower right-hand edge of the sphere. Reflected light cannot be as bright as direct light, but is generally very much darker in tone.

More Difficult Exercises. A series of exercises graduated in difficulty, should be gone through, until the student is able to execute a shading of a cast as difficult as that in **397**, or of a group of objects like that in **396**. The intermediate groups might consist of casts of fruit, foliage, or conventional ornament, or of objects to be found among household utensils, etc. For example, two bricks and a hammer or trowel, a cup and saucer, a glazed teapot, a cocoanut and a wooden mallet, a candlestick and box of matches, a piece of drapery hanging in graceful folds, etc. Make all drawings fairly fill paper not less than 22 × 15 in.

Another Method of Shading with Stumps and Chalk. **402–406** show the different stages of a more rapid method of stumping chalk shading. In **402** it will be seen that details of drawing are omitted, because they can just as easily be drawn with the stump when shading. The outline must not be too faint or too lightly drawn, or it will be lost altogether when the next stage is done. The even tone as shown in **403** is put on with either a very large stump, or, better still, with a pad made of a piece of chamois leather tied round some cotton-wool, so that it is like a ball rather larger than a walnut. Rub the pad in some chalk, and then on an odd piece of paper, until the correct evenness and value of tone can be made. Rub the pad all over the drawing and a little outside it, so that an evenness of tone (not too dark), is obtained, and the extra tone outside may be rubbed out with the indiarubber, leaving the outside edges of the drawing fairly sharp. In the third stage pick out all the chief light tones with the pointed rubber, as shown in **404**, being careful to draw the correct shape of each light, with its varying degree of intensity and different value of edge, now sharp, now soft, etc. **405** shows the main shadows and shades put in with the stump in a broad and simple manner. Leave out all details at this stage; endeavour, by careful and intelligent observation of the cast or object, to represent the chief planes of the surfaces with their varying tones, and draw them of some definite shape, perhaps triangular in one place, rectangular in another, and so on. With searching observation the student will soon overcome the difficulty of *seeing* where one tone merges into another, even when the difference of value is very subtle. Only blend one tone with the next when it is absolutely necessary. Correct values and good drawing of the varying tones must be the guiding principles at this stage. Finally finish Stage V. as shown in **406**, give attention to the necessary details and values of edges, blend one tone with another, if required, and give much care to the modelling of the lightest tones.

Continued

Continued from page 1390

THE PROCESSES OF CARDING

The Theory and Purpose of Carding. Cards and Combs. The Carding Engine. Card Grinding and Setting. Condensing and Scribbling

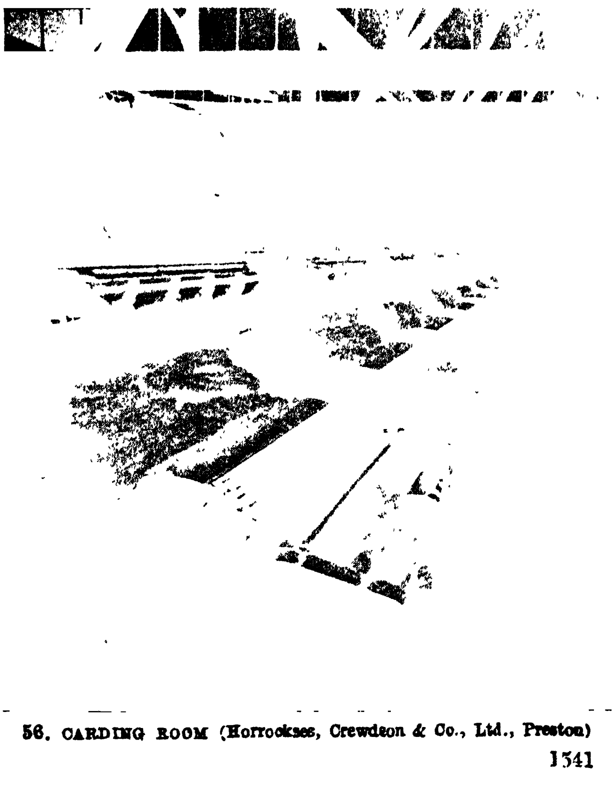
By W. S. MURPHY

EXCEPTING raw silk alone, every textile fibre must be carded. Silk is a filament from the beginning—the silkworm has combined the fibres into one continuous thread; other fibres are short, and to get a thread we require to join them together in some way. A thread is a thin line of fibres combined so as to possess a certain measure of coherence and consistency. To produce even the smallest section of such a line, the fibres must be laid out straight. It might be possible to devise means of stretching each separate fibre in this way; but the effect would be to make a series of little threads not longer than the length of the natural staple or growth of the fibre. This would hardly serve our purpose, even if it were possible. In cotton, for example, the minimum length demanded is a thread 15,000 times longer than the longest cotton fibre. Laying the fibres out singly or in little groups is not enough; we want to join the ends of the fibres together in some way.

Suppose we have two groups of fibres, all of the same length, and all laid nicely parallel, placing the ends of these two sets in contact would not join them; by bringing the extremities together you are avoiding the jointing powers they naturally possess, for the serrations are at the sides of the fibres. But pull one fibre of group No. 1 into group No. 2; draw up a fibre half-way from the second into the first; repeat the act, and you will see that connection has been established between the two —that, in fact, those four fibres have practically made the separate groups into a continuous whole. Carry out the idea fully, and an even thread will be formed about two-thirds the length of the two groups, but thicker in proportion

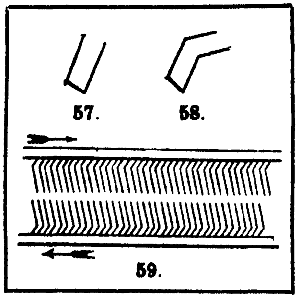
A Pivot Operation. Our object in carding, it appears, is not merely to disentangle matted or mixed fibres, but to bring them into such relations that they may readily combine together. A view of a modern carding room is given in 56. Carding is the pivot operation of textile manufacture; here the staples, or tufts, of the different fibres cease to tangle with each other and the thread begins. We pull the fibres out of their mutual tangles and snarls, bringing them into parallel lines, but at the same time keeping them always in lineal connection, forming them into a gauzy film, the filaments of which hold each other lightly yet intimately. If we gather that gauze into a continuous length, the disconnected character of the fibres disappears, and, instead, the continuous line we call *thread* commences. This is accomplished on the machines we call *carders*.

Kindred Processes. In a process which is continuous and gradual, it is difficult to mark definite points of division; in respect of one particular or another, we are bound to cross any border line which may be set. For example, the combing machine works on a different principle from the carder, pure and simple, but its object is the creation of the sliver; the spreader of the flax fibre seems to stand midway between the carder and condenser, but it also creates the sliver. We consider them all as one class, because the function of each and all is to act as the medium between the fibre as staple and the fibre as thread. The correctness of that division will appear more and more clearly as we proceed.



56. CARDING ROOM (Horrockses, Crewdson & Co., Ltd., Preston)

Cards and Combs. The first carding tool was what we now call a *comb*. Very probably it resembled rather a small hackling comb, with the difference that, instead of being fixed, it was held in the hand. By the process of adjustment with which we are now familiar, the comb changed its form according to changing use or new ideas. Up till the middle of the eighteenth century the wool-comb was the only carder the wool manufacturer knew; but the linen and cotton spinners had devised what were called hand cards. It was from these, in the first instance that development began. Hand cards are small boards full of spikes, with a handle at the one side. Holding one in each hand, with the faces together, the carder could give the fibres laid between a firm combing, or carding. In 1748 Lewis Paul, a Northampton manufacturer, invented a mechanical carder which undoubtedly gave his great successor, Richard Arkwright, the idea for the carding engine. He fixed little iron points in broad belts of leather, and nailed them round cylinders. Two of these cylinders he set together, so that the one would work in close proximity to the other, the curved teeth pulling in opposite directions. Arkwright seized on the idea, and, after working at it for several years, took out a patent in 1775. There was no comparison between the splendid and efficient carding engine of Arkwright and Lewis Paul's original carder; but the great cotton spinner had stirred up enemies by his success, and the patent was assailed successfully. It is with Arkwright's carding engine, improved in numerous details, that we work to-day.



CARD TEETH

The Carding Engine. The most interesting feature of the carding engine, and the instrument of its usefulness, is the card clothing, to which attention is first directed. The cloth, or clothing, itself may be of hard leather, indiarubber, or some special composition; but it must be absolutely uniform throughout in thickness and weight. Now look at the teeth. Originally a piece of fine steel wire [57], bent to form two right angles, something like a staple with a square head, this pair of teeth have been given another bend, half-way up the length of each leg, forming equal obtuse angles [58]. In the leather, or other basis of the card clothing, holes are cut to let the teeth through, and when set they show on the upper surface what look like hooks with straight points. Fill the whole area of the cloth or leather with these hooks, or teeth; make as much card cloth as is needed to cover all the rollers and cylinders of the carding engine. We are purposely vague, for the moment, because there are various kinds of engines, and it is only carders in general with which we have to do at present.

Card Teeth. Suppose we make two sheets of that carding cloth move close to each other in opposite directions [59], the teeth oppose each other; if any fibre were caught between those opposing teeth, it would certainly be pulled apart, and very finely drawn out. Obviously, if this action were repeated often enough, the fibres would all straighten out and lie in one direction. But there are several other ways of working those cards. Not to be too complex, we shall take only the contrary instance, because it is fundamental also. When the hooks are turned in the same direction, no action results, if the cards are run at the same speed. But suppose that one card be slow and the other fast; then any fibre held in the teeth of the slow card will be taken away by the swift one. It is the same action as you take in unhooking anything; travelling in the same direction as the curve of the hooks, the swifter one naturally disengages the fibres from its neighbour.

Card Clothing. We have confined our attention to a single set of carding teeth; but there are thousands in every cylinder and hundreds on every roller on the carding engine, and each hook must be level with every other. If one hook stands up above the others, it will take more than its share of the fibres, and cause irregularity; if the cylinders are not absolutely true, still more mischief is caused, for at one point the fibres will be missed and at another they will be torn and broken, because the teeth cut into each other. We must leave to the engineer the foundation and balance of the engine itself. But every carder and textile manufacturer should be able to do his own card clothing. Having carefully measured the cloth, which is generally put on in bands the circumference of the cylinder or roller, the cylinder should be placed on the engine, and the cloth stretched over it. When fully stretched, and jointed exactly edge to edge, the places for the nails should be marked, the cloth taken off and the nails driven through. Lay on the cloth again, and with the aid of the tools commonly used fix the cloth in position. Band after band is laid on in this way, and the cylinder is completed. If rings of card only are to be fixed, as in the case of what are called doffer cylinders, or on condensers, great care must be taken to make all the rings equal and at equal distances on the roller. We shall see the reasons for these things when we begin to work the various carders.

Card Grinding. Card hooks, or teeth, require to be pointed. Here occurs a difference of opinion among expert practical men. Some hold that the points of the teeth ought to be needle-pointed, and others hold the opinion that they should be flat or chisel-pointed. Whichever may be favoured, the main matter is that the points must all be equal and level. Possibly, the best results can be obtained from careful grinding on the emery cylinder, and then taking the roughness off by wearing. While it leaves a slight loophole for slovenly clothing to say so, it may be said that the function of the emery grinder is not only to sharpen, but also to level down the teeth. There are several machines for this purpose, but the one we illustrate [60] seems to us the best. By this machine the whole cylinder is ground at once. If the cylinder be laid in truly, and the emery kept in good condition, a fine, sharp, and even surface should result

Card Setting. This, and the relative finenesses of the teeth, may be discussed with more profit and detail when we deal with the different fibres. We use a very different quality of card clothing for fine cotton from that used for carding flax tow. The simple and broad principle of card setting should here be laid down, however. The intervals of space between the rollers should be carefully determined according to the length of the fibre being carded. A short fibre requires that the rollers and cylinders be in close proximity; long fibres, on the other hand, should be allowed wide intervals. By the observation of this rule, simple as it looks, much trouble is avoided.

Cotton Carding Engine. First to be built, the cotton carding engine has been very little improved upon during the past hundred years. Some few details have been added, and we have acquired better methods of both constructing and driving the machine, but in essential constitution it remains as Arkwright left it. One difference, however, is worthy of note, and that is the introduction of what are called *carding flats*—flat coverings extending sometimes over the whole engine, and in many cases over a section. Let us look at the roller engine for a moment, however, and then we will understand better the additions and improvements.

Weighed accurately on the scutcher, the fleecy lap of cotton is hung on the fore end of the carding engine, and drawn slowly out by the feed rollers. Behind these rollers revolves a card-covered roller, travelling at the rate of 800 feet per minute, named the "licker-in," which takes away the cotton in flakes. Further behind, and in the centre of the machine, runs the great cylinder, having a surface speed of about 1,500 feet per minute. Travelling almost in touch with the licker-in, and in the same direction, but at nearly double the speed, the main cylinder scoops away the cotton from the smaller cylinder.

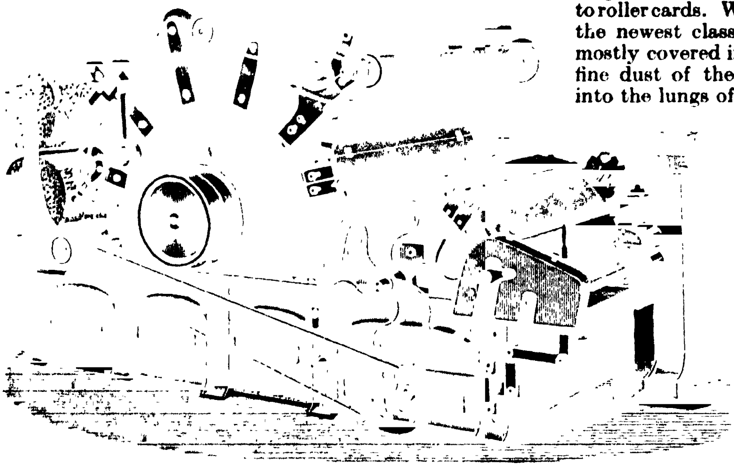
Dirt Roller. Running in an upward direction, the cylinder is carrying off its spoil, when another roller, set just above the licker-in, and in close proximity to the main cylinder, intervenes and takes away as much cotton as it can carry from the latter. This is called the dirt roller, because it plays the most important part in taking out any dirt that may have remained in the cotton after scutching. Though revolving in the opposite direction from the licker-in, the surface of this roller, at their point of contact, is travelling in the same direction as the main cylinder, or "swift." We want this second roller to steal away cotton from the swift, and say that it does so; the question comes, how can it? Its speed could be increased, of course, and then the hooks could steal up on the hooks of the main cylinder and gently rob in that way. This expedient, as will shortly appear, is not practicable in the circumstances. A better method has been devised. The teeth of the dirt roller are put in the reverse way, and the speed of its revolution is only ten to fifteen feet per minute. Compare the speeds, and you will see that, although both travelling in the same direction, the smaller roller exercises an enormous pull on the large one, with its reversed teeth.

Strippers and Workers. A still smaller roller, called a stripper, is running like a satellite above the dirt roller, and in even closer contact with the large cylinder. Revolving contrary to the dirt roller, with teeth set in the direction of its revolution, the stripper runs at the rate of 400 feet per minute. The teeth of the stripper moving in the same direction as those of the dirt roller, and more swiftly, it picks all the cotton out of the roller's teeth and flings it back to the large cylinder. But our big cylinder does not keep its spoil long. Another roller of the same character and construction as the dirt roller, and more respectably named a "worker," is running a little above that kind stripper, and almost immediately the cotton is being torn off the cylinder by the reversed teeth of this worker. Like a swift half-back watching a big, slow forward on the football field, the next stripper overtakes the worker as it is carrying off the cotton, takes it away and gives it back again to the cylinder. Other six workers and strippers, sometimes eight, repeat the game round the whole upper half of the cylinder, taking and losing, giving and spoiling, in mutual play. At the back of all, and moving slowly, with fine teeth curved in the direction of its motion, is the "doffer" cylinder. The revolution of the doffer is in the same direction as that of the main cylinder; but being smaller in diameter, and consequently having a reduced surface speed, its long teeth search into the cylinder teeth, picking out the

60. CARD GRINDING MACHINE
(Platt Bros. & Co., Oldham)

cotton and pulling it round itself like a fleecy mantle.

But here the give and take does not end. Oscillating to and fro on the under-surface of the doffer cylinder is a toothed comb that rapidly draws off the cotton in a fine film. This film is variously accepted, as we shall point out; but in the meantime, as we are in pursuit of the sliver, we may let it go in that way. Our filmy web is the same breadth as the cylinder; but it is gathered to a point and passed through a funnel, and thence two pairs of small rollers drag it out, forming it into a flat riband at the same time. The point of the riband is inserted into a vertical slit in a piece of iron; two rollers beyond round it off, and drop it, a fine sliver, into the waiting can—a tall tin cylinder, into which the sliver coils neatly.



61. REVOLVING FLAT CARDING ENGINE (Platt Bros. & Co., Oldham)

Carding Flats. Very soon after the carding engine was made a complete machine, cotton spinners devised a contrivance for assisting the workers and strippers. Half the upper part of the main cylinder was covered by a flat sheet of card cloth, set so as to hold the fibres till they were drawn straight. The teeth of the flat were set so as to oppose the teeth of the cylinder, but not so closely as to check them. In the opinion of many, the flat appeared to be more efficient than the rollers, and gradually what is called the revolving flat was developed. Without entering into a long discussion of this highly technical matter, we may say at once that the revolving flat carding engine [61] undoubtedly seems to serve well for carding the highest qualities of cotton.

Instead of the rollers already described, an endless lattice band of card cloth runs over the central cylinder, the teeth pulling uniformly in a straight line. Attached to the card lattice is a set of cleaning rollers, which, as the one half of the flat comes up from working, cleans it of adhering cotton. The ratchet motion that makes the flat revolve imparts an alternate movement to the cards, varying the drawing action of the teeth. From many points of view, the revolving flat carding engine is the highest form of that class of machine. Being self-cleaning, it obviates the dust and delay attendant on the frequent cleanings which we must give to roller cards. Working automatically, the newest class of those engines are mostly covered in, thus preventing the fine dust of the cotton from getting into the lungs of the workers.

Breaker and Finisher. For the sake of simplicity and clearness, the single carder has been studied alone, as if no other engine existed. Now a step further may be taken. The first carding is not enough for most textile purposes; it is usually called the *breaker*—that is, the breaking-in card, and the next is called the *finisher* card. Many spinners couple the two together, and run the cotton direct from the one to the other; but this practice is objected to by others, who contend that it is neither economical nor efficient. The ideal is the automatic; but perhaps we have been in too great a hurry in attempting to realise it. Machines must be perfect in detail before they can be trusted to work without check or supervision. If we have to work with two single carders, one breaker, and one finisher, a lap-forming apparatus, such as we saw on the scutcher, must take the place of the sliver-forming appliance on the breaker engine; if the two engines are coupled, the doffer between the two acts simply like a larger, more drastic, worker roller. Practice varies a good deal, however, and dogmatism on such a matter would not be wise.

Carding and Condensing the Wool. When the wool manufacturer accepted the carding engine from the cotton industry, he found that it would not deal with his material in a very satisfactory manner. Longer in staple and more deeply serrated than cotton, the wool was injured by the keen teeth of the cotton carder. As usual in such cases, there was a strong recoil from the instrument which had been so eagerly welcomed and which had so cruelly disappointed hope. The hand comb was reverted to, and in many factories, so strong was the prejudice against machines, hand combing was practised up till about 1870. Considering the number of fine carding and combing machines then on the market, this is amazing, but it must be accepted as evidence of the difficulty of restoring confidence after it has been once broken. Two prime facts appeared in this connection. One was that the carding rollers, having to deal with a longer staple, required to be set further apart than in the cotton carder ; the second was that there are some wools which ought not to be treated by carding, or, if treated, only in the gentlest, lightest fashion. Following hard on the discovery and negotiation of these facts came another—*viz.*, that the readjustment of the rollers demanded some difference in the form of some of them, and so a wool carder, differing in some details from the cotton carding engines, came into existence.

The Scribbler. Observe already the difference in nomenclature. The breaker card of the cotton spinner has become the scribbler [63] of the wool spinner. When our wool came from the "fearnought" teaser, it had merely received its last mixing and opening and cleansing ; the measuring of quantities, so important in all textile operations, has yet to be done. Various devices for measuring the wool as it is fed to the scribbler have been adopted. The simplest is the marking on the feed-board of the space properly occupied by the regular thickness of a given quantity ; but this method puts too much reliance on the skill of an operative not paid at the rates which skilled labour usually commands. The best and simplest arrangement we have seen for regulating the feed is a kind of weighbridge lattice feed. While the quantity to be fed is coming forward, the scribbler is stationary ; as soon as the quantity is heaped on the feed-board it overcomes the counter-weight and bends over, loosening the clutch that controls the drive, and inclining the wool to the feeder rollers Instead of the simple feeders of the cotton carder, we have here three rollers, one set above the other, all clad with teeth, and these begin at once the carding operation, pulling and drawing the fibres among themselves. The advantage of this is obvious. With such a long staple, delivery is not easy, and by carding out at the point of delivery a better start is obtained. The rollers are set at wider intervals ; but, except in one other particular, the scribbler is precisely the same as the roller carding engine already detailed. The particular point of difference is interesting and important. Wool has very strong clinging properties, and the ordinary doffing cylinder would be useless unaided. Beneath the last stripper roller of the series revolves a curious roller, called the "fancy" (K), with long, finger-like wires that pick into the teeth of the main cylinder, loosening its hold on the fibres, and making them yield easily to the pull of the doffing cylinder moving below.

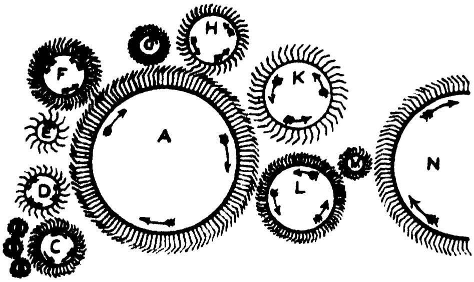
Doffers. As in the case of cotton, there are several modes of treating the cardings as they come off the doffing comb. If the wool is to be made into felt, it is rolled into a lap, similar to that taken from the scutching machine ; if designed for worsted, it is formed into a sliver ; and if intended for further carding and the condenser, the fibres may be formed into a lap, drawn out into a sliver, or doffed directly on to the adjacent carder. There is yet another mode peculiar to woollen manufacture. One of the few contrivances in textile manufacture we have received from America is this appliance. In a hopper on the top of a small machine sits a range of thick cylindrical bobbins, one of which descends into the grip of a pair of discs in the middle of the machine. Up to the disc extends a revolving tube. From the doffing apparatus the sliver is led into this tube, and it winds up round the bobbin held in the discs, which are now revolving. As soon as the bobbin is filled, it automatically drops out, and another from the hopper drops into its place. Some establishments use these bobbins as feeds for the condenser, when working on low-class goods.

Intermediate Carding. In the most highly organised factories, an intermediate carder is used and linked on to the scribbler in a very curious way. Not only because the use of the intermediate carder seems to us a good practice, but because the method of linking is highly interesting and promising, we shall observe it. When the sliver is given off by the

As Delivered

2. COTTON SLIVER IN DIFFERENT STAGES

scribbler, it is taken away by a lattice which conveys it up above the feed of the intermediate carder in front of which moves to and fro a travelling carriage. The sliver descends on to this carriage, and it lays the filmy skein across the feed lattice of the carder in long folds, obliquely overlapping one another, yet preserving a uniform thickness. The reason for this act brings us to the mark of difference between the woollen and the worsted thread. Woollen threads are composed of fibres intimately interlaced; worsted threads are composed of parallel fibres twisted together. Therefore the object of the woollen spinner is to obtain an intimate combination of fibres at the earliest possible moment. The working of the intermediate carder is exactly that of the scribbler.



63. DIAGRAMS OF LONGITUDINAL SECTION OF WOOL CARDING MACHINE

A. Breast Cylinder. B. Feeders. C. Dirt Roller. D. Licker-in. E. Stripper. F. Worker. G. Stripper. H. Worker. K. Fancy. L. Doffer. M. Angle Stripper. N. Doffing Roller

Condensing. We have pictured all the carders as separate, but it must be clearly understood that this has been done only for the sake of clearness and simplicity. A frequent practice is to link the successive carders together, with only the doffer roller (N) between. The finisher card is of the same construction, in all essential particulars, as the scribbler and intermediate; the only difference is in the finer teeth. At the end of the finisher carding engine, the condenser machine is set. First note the form of the doffing cylinder; it is equipped with strips of carding teeth, alternated with spaces of equal breadth. As the doffer comb plays on these strips, it draws off a row of thin, filmy ribbons. From beyond the comb, stretched parallel to the length of the machine, run endless bands of card-cloth, and by these the thin slivers are carried along, the teeth holding them in unity, to where revolves a broad, endless belt of leather or indiarubber composition. This, also, is moving away from the cylinders, and draws the slivers on. There is a certain amount of tenacity in the surface of the belt, and the fibres tend to cling to it. Near the edge of the broad belt the first of a series of rollers revolves, and it rubs and presses on the slivers, reducing them in size and enhancing their consistency. A pair of these rollers come next, and under their kind attentions the slivers assume almost the form of threads. Another pair perform the same office, and then the threads pass through a guide comb, and on to large bobbins. Now let us go back a little, and observe the details more closely. At first glance we can see that all the rollers vary in speed of motion, every successive one being quicker than its preceding neighbour. But the action of the rollers is not simply forward; every one of the whole series moves to and fro transversely, with an oscillating motion. The effect of this action is easy to understand. It is the same as if you took a wisp of fibres and rubbed them together between the palms of your hands; the fibres are rolled and rubbed close together, while the revolution of the rollers draws them out lengthways. The result of this action is a fine thread; for rough tweeds and heavy woollen cloths, no more is required than to give the threads a spin on the mule frame, and then the yarn is ready.

Continued

CUBIC CONTENT: PROBLEMS

Carpeting Floors and Papering Walls. Cubical Content and Problems connected therewith. Time, Distance, and Speed

Group 21
MATHEMATICS
11

Continued from page 1443

By HERBERT J. ALLPORT, M.A.

CARPETING FLOORS AND PAPERING WALLS

155. All problems on carpeting floors, papering walls, painting surfaces, etc., depend on the same thing—*viz.*, that length × breadth = area.

In the carpeting of floors, an arithmetical question always assumes that the floor is a rectangle, and no allowance is made for "matching" the pattern of the carpet. The carpet is taken from a long roll of given width, and all the student has to do is to find what *area* of carpet is required (by multiplying together the length and breadth of the room) and then to find what *length* must be cut from the roll to supply this area (by dividing the area by the width).

The cost of the carpet is generally given as so much per linear yard. Then, since the number of yards required is known, the total cost of covering the floor is easily found.

Example 1. Find the cost of covering a floor, 18 ft. long, 15 ft. broad, with carpet 27 in. wide, at 4s. a yard.

Area of carpet required $= 18 \times 15$ sq. ft.
Width of carpet $= 27$ in. $= 2\frac{1}{4}$ ft.

$$\therefore \text{Length reqd.} = \frac{18 \times 15}{2\frac{1}{4}} \text{ ft.} = \frac{18 \times 15}{2\frac{1}{4} \times 3} \text{ yd.}$$

$$\therefore \text{Cost} = £\frac{18 \times 15 \times 4}{2\frac{1}{4} \times 3 \times 20}$$

$$= £\frac{\overset{2}{\cancel{18}} \times \cancel{15} \times \cancel{4} \times 4}{\cancel{9} \times \cancel{3} \times \cancel{20}} = \underline{£8 \quad \textit{Ans.}}$$

Notice that the *length* of carpet is *linear* feet, and therefore we divide by 3, not by 9, to reduce it to yards. The cost is found by multiplying the number of yards by the price of a single yard—*i.e.*, 4s. This would give the answer in shillings. We therefore put 20 in the denominator, to reduce the amount to £'s.

It should be particularly noted that there is no need to work out any portion of the sum until we get to the cost. We do not want to know the actual area of the floor, or the actual length of carpet required.

Example 2. A room 21 ft. square has the middle covered with a carpet 16 ft. square, at 9s. a square yard, and the space round the carpet is stained, at 10d. a square foot. Find the total cost.

Area of floor $= 21 \times 21$ sq. ft. $= 441$ sq. ft.
Area of carpet $= 16 \times 16$ sq. ft. $= 256$ sq. ft.
$\therefore$ Area to be stained $= 441 - 256 = 185$ sq. ft.
$\therefore$ Cost of staining $= 1850$d. $=$ £7 14s. 2d.
Price of carpet $=$ 1s. per sq. ft.
$\therefore$ Cost of carpet $=$ 256s.
$=$ £12 16s.
$\therefore$ Total cost $=$ £7 14s. 2d. $+$ £12 16s.
$= \underline{\text{£20 10s. 2d. } \textit{Ans.}}$

The student must be careful not to confuse the two expressions, "21 feet square" and "21 square feet."

156. The simplest way of finding the area of the walls of a room is to find the distance round the floor, or the *perimeter*, and multiply by the height. This is equivalent to placing the four walls into one long wall, and multiplying the length by the height to obtain the area.

Thus, a room 18 ft. long, 15 ft. broad, 10 ft. high, if measured round the four sides of the floor, would give $(18 + 15 + 18 + 15)$ feet for the length of our "imaginary" wall. Therefore, the area of the four walls is $(18 + 15 + 18 + 15) \times 10$ sq. ft.; or

Twice (Length + Breadth) × Height = Area of

The problem of finding the cost of papering the room is now the same as that of carpeting a floor. We have only to divide the area of the walls, which is the area of paper required, by the width of the paper, and we obtain the length of paper required. Then, when we know the price per yard, the cost of the entire amount is easily found.

Example. Find the cost of papering a room 24 ft. long, 18 ft. wide, 12 ft. high, with paper 21 in. wide, at 2s. 9d. per piece of 12 yd.

Area of walls
$= 2\,(24 + 18) \times 12$ sq. ft. $= 2 \times 42 \times 12$ sq. ft.
Width of paper $= 21$ in. $= 1\frac{3}{4}$ ft.
Therefore, Length of paper required

$$= \frac{2 \times 42 \times 12}{1\frac{3}{4}} \text{ ft.} = \frac{2 \times 42 \times 12 \times 4}{7 \times 3 \times 12} \text{ pieces.}$$

Therefore, Cost

$$= £\frac{\cancel{2} \times \overset{\cancel{2}}{\cancel{42}} \times \cancel{12} \times \cancel{4} \times \overset{11}{\cancel{33}}}{\cancel{7} \times \cancel{3} \times \cancel{12} \times \underset{5}{\cancel{240}} \times \underset{\cancel{3}}{\cancel{12}}} = £\frac{11}{5} = £2\ 4\text{s.}\ \textit{Ans.}$$

CUBICAL CONTENT

157. We have now to consider the measurement of volume, or solidity. Just as the rectangle is the chief surface considered in arithmetic, so the *rectangular solid* is the chief solid body.

A rectangular solid is bounded by six rectangular surfaces, each opposite pair of rectangles being equal and parallel to each other.

A rectangular solid thus has *three* dimensions—*length*, *breadth*, and *thickness*.

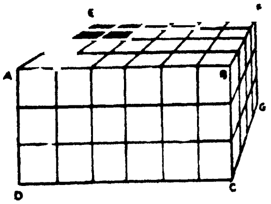
If the length, breadth, and thickness are all equal to one another, the solid is called a *cube*.

Hence, a *cubic foot*, the unit of volume, is a solid body whose length, breadth, and thickness are each a linear foot. Similarly, a cubic inch measures one linear inch in length, breadth, and thickness; and a cubic yard measures one linear yard in length, breadth, and thickness.

158. The number of cubic feet (or inches, or yards) in the volume of a rectangular solid is equal to the number of linear feet (or inches, or yards) in the length, multiplied by the number of linear feet (or inches, or yards) in the breadth, multiplied by the number of linear feet (or inches, or yards) in the thickness.

This is usually abbreviated into

Length × Breadth × Thickness = Volume, or Cubic Content.



For, suppose the solid in the diagram is 6 ft. in length, 4 ft. in breadth, and 3 ft. in thickness. It is clear that the solid can be cut into three slices, each 1 ft. thick, by planes parallel to the face ABFE. But, by Art. 153, the face ABFE contains 6 × 4 sq. ft., and under each square foot there is a cubic foot. Thus, each slice contains 6 × 4 cubic ft. Therefore, since there are three slices, the whole solid contains 6 × 4 × 3 cubic ft.

159. Since,

Length × Breadth × Thickness = Cubic Content,

it follows that, if we know any three of these four quantities, we can find the fourth.

160. The student should remember that

(*a*) A cubic foot of water weighs 1000 oz. (avoir.), approximately.

(*b*) A gallon of pure water weighs 10 lb. (avoir.), or,

"A pint of clear water
Weighs a pound and a quarter."

We have thus a relation between weight, capacity, and cubic content.

Example 1. A tank 7 ft. long, 6 ft. broad, is filled to the depth of 2 ft. with water. How many gallons of water are in the tank?

Amount of water = 7 × 6 × 2 cubic ft.

$$= \frac{7 \times 6 \times 2 \times 1000}{16} \text{ lb.}$$

$$= \frac{7 \times \overset{3}{\cancel{6}} \times \cancel{2} \times \overset{25}{\cancel{1000}}}{\underset{4}{\cancel{16}} \times \cancel{10}} \text{ gal.}$$

$$= \underline{525 \text{ gals. } Ans.}$$

Example 2. An open tank made of iron ¼ in. thick, is 4 ft. long, 2 ft. 6 in. broad, and 2 ft. deep, outside measurement. Assuming that iron weighs 7·8 times as much as water, find the weight of the tank.

The external volume of the tank

$$= 2 \times 2\tfrac{1}{2} \times 4 \text{ cubic ft.} = 20 \text{ cubic ft.}$$

Since the iron is ¼ in. thick, the inside length is ½ in. less than the outside, the inside breadth is ½ in. less than the outside, and the inside depth is ¼ in. less than the outside.

Therefore, the interior volume

$$= 29\tfrac{1}{2} \times 47\tfrac{1}{2} \times 23\tfrac{3}{4} \text{ cubic in.}$$

$$= \frac{59 \times 95 \times 95}{16} \text{ cubic in.}$$

$$= 33279\tfrac{11}{16} \text{ cubic in.}$$

Therefore, volume of iron in the tank

$$= 20 \text{ cubic ft.} - 33279\tfrac{11}{16} \text{ cubic in}$$

$$= 1280\tfrac{5}{16} \text{ cubic in.}$$

But 1 cubic ft. of iron weighs as much as 7·8 cubic ft. of water, *i.e.*, 7·8 × 1000 oz., or 7800 oz.

$$\therefore \text{ Weight of tank} = \frac{1280\tfrac{5}{16} \times 7800}{1728 \times 16} \text{ lb.}$$

$$= \underline{361\tfrac{3673}{18432} \text{ lb. } Ans.}$$

Example 3. The areas of the faces of a rectangular solid are 35 sq. ft., 21 sq. ft., and 15 sq. ft. respectively. Find the length of each edge.

The areas of the faces of a rectangular solid are (i.) length × breadth; (ii.) breadth × depth; (iii.) length × depth. If we multiply these together we obtain $(\text{length})^2 \times (\text{breadth})^2 \times (\text{depth})^2$, and the volume of the solid is the square root of this product.

Hence, the volume of the given solid

$$= \sqrt{35 \times 21 \times 15} \text{ cubic ft.}$$

$$= \sqrt{3^2 \times 5^2 \times 7^2} \text{ cubic ft.}$$

$$= 3 \times 5 \times 7 \text{ cubic ft.}$$

Therefore,

$$\left.\begin{array}{l} \text{Length} = (3 \times 5 \times 7) \div 15 = 7 \text{ ft.} \\ \text{Breadth} = (3 \times 5 \times 7) \div 21 = 5 \text{ ft.} \\ \text{Depth} = (3 \times 5 \times 7) \div 35 = 3 \text{ ft.} \end{array}\right\} \underline{Ans.}$$

162. We have seen [Art. 153] that surface is of *two* dimensions—*i.e.*, we find the area of a rectangular surface by multiplying *two* quantities together. If, then, we have two rectangles, of which one is twice the length and twice the breadth of the other, the *area* of the first will be 2^2, or 4, times the area of the other. Or, if the dimensions of the first are 3 times the dimensions of the second, the area of the first will be 3^2 times the area of the second.

Similarly, since cubical content is of *three* dimensions, if we have two rectangular solids in which the dimensions (length, breadth, thickness) of the first are any multiple, say 3 times the dimensions of the second, the *volume* of the first will be 3^3, or 27, times the volume of the second.

But it should be noticed that *area* of the six surfaces of the first solid will only be 3^2, or 9, times the area of the surfaces of the second.

Example 1. The cost of thatching varies as the area thatched. If it costs £4 to thatch a stack 16 ft. high, how high is a *similar* stack which it costs £2 5s. to thatch?

£2 5s. is $\frac{9}{16}$ of £4. Therefore the area thatched in the second case is $\frac{9}{16}$ of that thatched in the first case. Hence, each dimension of the second stack is $\sqrt{\frac{9}{16}}$, or ¾, of the corresponding dimension in the first stack.

But, the first stack is 16 ft. high, therefore the second is ¾ of 16 ft., or 12 ft. high *Ans.*

Example 2. What is the value of a silver coin *similar* to a sixpence, but twice as thick ?

The coins are similar, so that every dimension (*viz.*, length, breadth, and thickness) of the one is twice the corresponding dimension of the other. Therefore the content of one coin is 2^3 or 8 times the content of the other.

Hence, the value of the second coin is 8 × 6d. = 4s. *Ans.*

Example 3. The dimensions of a rectangular box are as 3 : 4 : 5. The difference between painting the outside at 6d. and at 7d. a square foot is 17s. 7½d. Find the dimensions of the box.

Suppose the box to be 3 ft. × 4 ft. × 5 ft. The total area of the six faces would be

$$2\{(3 \times 4) + (4 \times 5) + (3 \times 5)\} \text{ sq. ft.} = 94 \text{ sq. ft.}$$

But, the difference between the costs at 6d. and at 7d. a foot = 17s. 7½d. = 211½d.

Therefore, the actual area of the six faces is 211½ sq. ft.

Thus,

$$\begin{aligned}\text{Actual area} : \text{supposed area} &:: 211\tfrac{1}{2} : 94\\ &:: 423 : 188\end{aligned}$$

Therefore, each dimension of the actual box

$$\begin{aligned}&= \sqrt{\tfrac{423}{188}} = \sqrt{\tfrac{9}{4}}\\ &= \tfrac{3}{2} \text{ of the corresponding dimension of the supposed box.}\end{aligned}$$

Hence,

$$\left.\begin{aligned}\text{Length} &= \tfrac{3}{2} \times 5 \text{ ft.} = 7\tfrac{1}{2} \text{ ft.}\\ \text{Breadth} &= \tfrac{3}{2} \times 4 \text{ ft.} = 6 \text{ ft.}\\ \text{Depth} &= \tfrac{3}{2} \times 3 \text{ ft.} = 4\tfrac{1}{2} \text{ ft.}\end{aligned}\right\} \textit{Ans.}$$

EXAMPLES 19

1. A rectangular field, three times as long as it is broad, contains 30 acres. Find its length and breadth.

2. Find the cost of the paper for a room 17 ft. 9 in. long, 13 ft. 9 in. broad, and 10 ft. high, the paper being 21 in. wide, and its price 2s. 8d. per piece of 12 yd.

3. The floor of a room 21 ft. square has a square carpet in the middle, costing 5s. 3d. per sq. yd. The outside border is covered with oil-cloth at 2s. per sq. yd. Had the whole floor been covered with carpet, the cost would have been increased by £3 18s. Find the width of the oil-cloth border.

4. A rectangular cistern is 6 ft. long, 4 ft. wide, and 3 ft. deep inside measurement. Find the cost of lining it with lead, weighing 8 lb. to the square foot, at 10s. 2d. per cwt.

5. It costs £2 17s. 9d. to paper a certain room. What would the cost have been if the room had been twice as long, twice as broad, and half as high again ?

6. The cost of levelling and turfing a square cricket field at 10d. per square yard is £852 0s. 10d. What will it cost to surround the field with an iron fence at 8s. per yard ?

7. The dimensions of a rectangular box are as 7 : 5 : 3, and its volume is 13,125 cubic in. Find its dimensions.

TIME AND DISTANCE

163. The speed, or rate at which a body is moving, is measured by the distance through which the body would move in a given time.

Thus, when we say that at some particular instant a person is walking at 4 miles an hour, we mean that if he continues walking at the same pace as at that particular instant he will go 4 miles in the hour.

A person walking at the rate of 4 miles an hour, will go 8 miles in 2 hours, 12 miles in 3 hours, and so on. Hence,

$$\text{Rate} \times \text{Time} = \text{Distance} ;$$

and when we know any two of these quantities we can find the third.

164. In many questions on speed, it is useful to be able to convert readily "miles per hour," into "feet per second." For this purpose we shall first find what rate in feet per second is equal to 60 miles per hour.

60 miles per hour

$$\begin{aligned}&= 60 \times 1760 \times 3 \text{ ft. in } 60 \times 60 \text{ seconds}\\ &= \frac{\cancel{60} \times \overset{88}{\cancel{1760}} \times \cancel{3}}{\cancel{60} \times \underset{\cancel{2}}{\cancel{60}}} \text{ ft. per second}\\ &= 88 \text{ ft. per second.}\end{aligned}$$

Remembering this result, we can easily convert any other rate from miles per hour to feet per second. For example, 20 miles per hour is $\frac{20}{60}$ of 88 ft. per second, *i.e.*, $\frac{88}{3}$ ft. per second.

165. Suppose two persons walking along the same road, the first at 4 miles an hour, and the second at 3 miles an hour. Then, if they are walking towards one another, at the end of 1 hour they will have diminished the distance between them by 4 + 3 miles, *i.e.*, they approach one another at the rate of 7 miles an hour. Or, if the first person is following the second, at the end of 1 hour they will have diminished the distance between them by 4 − 3 miles, *i.e.*, they approach one another at the rate of 1 mile an hour. Hence, if we know their distance apart at any particular time, we can find how long after that time it will be before they meet.

Example 1. The distance between Edinburgh and London is 400 miles. At 12 noon a train leaves Edinburgh for London at 40 miles an hour, and 1 hour later a train leaves London for Edinburgh at 50 miles an hour. When, and at what distance from London, will they meet ?

At 1 o'clock, the train from Edinburgh has travelled 40 miles, so that, when the other train leaves London, the two are 400 − 40, *i.e.*, 360 miles apart. But they approach one another at the rate of 40 + 50, or 90 miles per hour.

Therefore, the time till they meet = 360 ÷ 90 = 4 hours after 1 o'clock.

In 4 hours the train from London travels 4 × 50 miles = 200 miles.

Hence, the trains meet at 5 o'clock, 200 miles from London. *Ans.*

Example 2. The rates of two cyclists are as 11 : 8. They start together from the winning post and race round a circular track. The better man passes the other every 4 minutes, and when the race ends they are passing the winning post together for the first time. How long did the race last ?

Since 11 and 8 are prime to one another, it is clear that they will first pass the winning post together when the first has ridden 11 times round and the second 8 times round.

The faster man thus gains 11 − 8, or 3, rounds during the race. But, he passes the other man every 4 minutes, *i.e.*, he gains 1 round in 4 minutes. Hence, he will gain 3 rounds in 3 × 4 minutes, *i.e.*, the race lasted 12 minutes *Ans.*

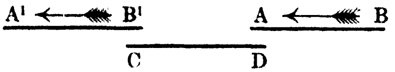
Example 8. Three men ride round a circular track 2112 yd. in circumference. The first goes 440 yd. a minute, the second 352 yd., and the third 344 yd. If they start together, riding in the same direction, how long will it be before they are together again ?

The first man gains on the second at the rate of 440 − 352, or 88 yd. per minute. Since the distance round the track is 2112 yd., the time till the first man again passes the second is 2112 ÷ 88, *i.e.*, 24 minutes.

Similarly, the first man gains on the third at the rate of 440 − 344, or 96 yd. per minute. He will, therefore, pass the third man again after 2112 ÷ 96, *i.e.*, 22 minutes. Hence, the first man will pass both the others together after the L.C.M. of 24 and 22 minutes, *i.e.*, 264 minutes, or 4 hours 24 minutes *Ans.*

166. In the case of a train of given length passing a certain point, or of two trains passing one another, we have to consider the distances travelled. It is clear that, in the first case, the train has to travel a distance equal to its own length, so that, knowing the length of the train and its rate, we can find the time taken to pass a given point.

In the case of one train passing another, the one train must *gain* on the other a distance equal to the sum of the lengths of the trains.



Suppose AB and CD to be two trains, and let the train AB be moving in the direction shown by the arrow. Then, whether the train CD be moving in either direction or whether it be standing, it is evident that when the two trains are again clear of one another, their relative position will be that shown by A¹B¹ and CD. Thus, the one train has travelled, relative to the other, a distance AA¹, which is the distance equal to the sum of the lengths of the trains.

Example. Two trains of lengths 77 yd. and 88 yd. are moving at 45 miles and 30 miles per hour respectively. Find how long they take to pass each other (i.) when they are moving in opposite directions ; (ii.) when they are moving in the same direction.

(i.) When they are moving in opposite directions their relative speed is

$$45 + 30 = 75 \text{ miles per hour.}$$

$$= \frac{75 \times 88}{60 \times 3} \text{ yd. per sec. [Art. } \mathbf{164}\text{].}$$

And, to pass one another, the one must move, relative to the other, through a distance 77 + 88 = 165 yds.

Hence, they will pass one another in

$$\left(165 \div \frac{75 \times 88}{60 \times 3}\right) \text{sec.} = \frac{\overset{\cancel{15}}{\cancel{165}} \times \overset{\overset{3}{\cancel{12}}}{\cancel{60}} \times 3}{\underset{\cancel{5}}{\cancel{75}} \times \underset{\underset{2}{\cancel{8}}}{\cancel{88}}} \text{ sec.}$$

$$= \frac{9}{2} = \underline{4\tfrac{1}{2} \text{ sec. } \textit{Ans.}}$$

(ii.) When they are moving in the same direction their relative speed is

$$45 - 30 = 15 \text{ miles per hour.}$$

$$= \tfrac{22}{3} \text{ yd. per sec. [Art. } \mathbf{164}\text{].}$$

Hence, they pass one another in $(165 \div \frac{22}{3})$ seconds.

$$= \frac{\overset{15}{\cancel{165}} \times 3}{\underset{2}{\cancel{22}}} = \frac{45}{2} = \underline{22\tfrac{1}{2} \text{ sec. } \textit{Ans.}}$$

167. In problems concerning the rate of a boat rowed with or against a stream the principle is the same.

If a man can row a boat, say at 4½ miles an hour in still water, and he rows *against* a stream whose rate is 1½ miles an hour, the actual rate of the boat will be 4½ − 1½, or 3 miles an hour.

Similarly, if he rows *with* the stream, the actual rate will be 4½ + 1½, or 6 miles an hour.

Example. A man rows 7 miles against a stream whose rate is 1 mile per hour in 1¾ hours. How long will he take to row back again ?

Against the stream he rows 7 miles in 1¾ hours

$$= \frac{7}{1\frac{3}{4}} = 4 \text{ miles per hour.}$$

But the stream hinders him 1 mile per hour; therefore, in still water he rows 4 + 1 = 5 miles per hour.

Hence, rowing down stream his rate is 5 + 1 = 6 miles per hour. Therefore, to row 7 miles he will take 7 ÷ 6 = 1⅙ hours = 1 hour 10 min. *Ans.*

Answers to Arithmetic

EXAMPLES 18

1. $3 \times 7 \times 13 = 273$.
2. $2^2 \times 17 = 68$.
3. $5^2 \times 11 \times 19 = 5225$.
4. 77.
5. $2^3 \times 3 \times 11 = 264$.
6. $5 \times 23 = 115$.
7. 314·27.
8. 1·7728 . . . = 1·773.
9. (i.) 314 ; (ii.) 210·063.
10. $\sqrt[3]{13\frac{203}{512}} = \sqrt[3]{\frac{6859}{512}} = \frac{19}{8} = 2\frac{3}{8}$.
11. 7·071 ft.
12. £19 5s. 4d. = 4624d. ∴ No. of books = $\sqrt{4624}$ = 68 *Ans.*
13. £6 2s. 6d. = 245 sixpences. Had he spent as many sixpences each day as there were days, he would have spent 245 ÷ 5 = 49 sixpences. ∴ the number of days = $\sqrt{49}$ = 7 days *Ans.*
14. Height of the top of the window above the ground = $\sqrt{50^2 - 14^2}$ ft. = 48 ft. Height of bottom of window above ground = $\sqrt{50^2 - 30^2}$ ft. = 40ft. Therefore, the window measures (48 − 40) ft. = 8 ft. from top to bottom.

Continued

Continued from p 1463

SUITS FOR THE SCHOOLBOY

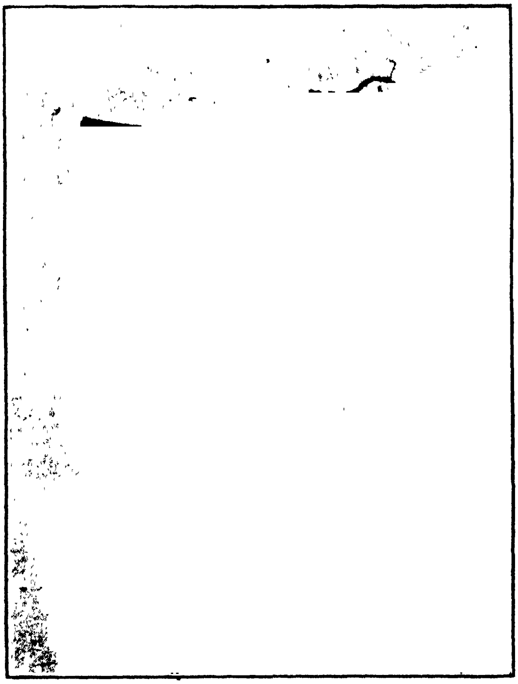
Making the Knickers—continued. **Joining the Legs. Linings. Drafting Boys' Suits. Making Coat with Step Collar**

By Mrs. W. H. SMITH and AZÉLINE LEWIS

To join the legs, turn the fore part over, right side uppermost; place the left back part on to face this and baste together from the knee to the waist, keeping the top and bottom together and basting close to the pocket mouth [48].

Stitch the seam (the back part must always be underneath when the seams are stitched); remove the basting; open, and press, slightly damping the seam with a moist rag. Baste the linen stay of pocket over the seam and fell to cloth, taking care not to let the stitches show through [see stay at pocket in 44]. Turn the leg over, and with needle and twist make a good bar tack (as worked on the ends of buttonholes) at the top and bottom of opening. This finishes the pockets, and we now turn our attention to the upper edge.

Baste a strip of linen canvas, 1½ in. wide, along the top of knickers ¼ in. from the edge, cut to shape, which can be joined if necessary. Baste this along twice, also pieces of double linen 1½ in. square where the buttons are to go [44]. Stitch round the top 1 in. from the edge; turn the top over and serge to canvas; turn over again, and stitch ⅛ in. from edge.



48. JOINING THE LEGS

Baste the inside leg seam together and stitch; open, and press. After preparing the right leg in the same way as for pockets, the outer leg seam, the waist and inner seam, baste the back parts together from the fly to the top, keeping the forks and tops even. Stitch twice, remove the basting, open, and press; turn up the bottoms of the knickers to the thread marks, and serge to cloth, taking care not to let the stitches show through, and press over a sleeve-board.

Work a bar tack on the bottom of fly ¼ in. from stitching, as described for the pocket ends, to keep this firm, and sew on the buttons as already described for coat. Cut the linings the same as cloth; stitch, open, and press seams, and arrange in the knickers in the way about to be described.

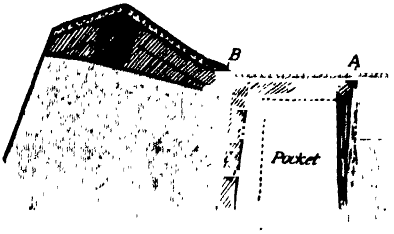
Inserting Knickers Lining. Place the back seam of lining to the back seam of knickers (both inside out), keeping them level at the forks and the top. Tack the two seams together at the top and bottom; open the knickers and lining flat on the table, tack the inside leg seams together at the bottom, with the linings rather loose, then tack the outside seams together at the top and bottom, still keeping linings loose.

Put the hand through one leg of the lining, take hold of the bottom of knickers leg, and draw through. Treat the other leg the same. Place the pockets level; tack the top of lining to the knickers; turn these towards the worker, with the top at the right-hand; turn the lining in round the button-catch, baste and fell to this.

Nick the lining at the bend on the buttonhole side, turn in the edge, baste and fell to this. Cut the lining away from the top, about ¾ in. all round. Take a strip of light silesia, 4 in. wide, for a waistband, and the length of this portion of the lining from front of fly, as from *a* in **44**.

Baste to the lining, right side underneath, and 1½ in. down from top; run on ¼ in. from the edge of waistband, holding it tightly whilst putting on, leaving ½ in. for turning in centre-back; place the other piece over it, and run on in the same way. Turn the waistband up and crease along with the thumb where sewn on; baste, cut the band off at the top, leaving ½ in. to turn in. Nick at the sides, as at B in Fig. **44**; turn in, baste and fell. Turn in the bottoms 1 in. from the lower edge of knickers, and fell to cloth.

Then give the knickers a final pressing in this way. Take each leg separately, fold the seams together, press over a damp cloth, and make a crease down the front and back [**45**].



44. UPPER EDGE OF KNICKERS

Suits for Boys from Eight to Ten Years. We have now to deal with suits for boys between the ages of eight and ten.

Breast 28 in.; waist 27 in.; neck 13 in.; back 14 in.; full length 22 in.; ¼ in. turnings are allowed on all seams. Scale, half breast, 14 in.

Drafting the Coat. Draw lines at right angles from A, B, C, D and E, as in previous drafts. C to C^a, ⅜ and ¼ in.; G to H, 3⅜ in.; G line to H^a, 3 in.; H^a to H^b, ½ in.; connect to neck curve. G line to P ⅜ in. more than G to H. K to I, one-twelfth (1¼ in.). Drop the front 1 in., and draw straight line to K. The corner can be curved off to any style preferred.

Complete shoulder, armhole curves, and side lines as in previous drafts.

Collar. Half an inch from M^a make 1; draw line from H through 1; 1 to 2, one-sixth of neck, plus ¼ in.; where this line crosses neck-curve make X. H^a to 3, 1 in.; 3 to 4, 2 in.; H^b to 5, 1¼ in.; 5 to 4, 1¼ in. Draw lines from 5 to 4 and 4 to 2. Square down from 2; 2 to 6, 1⅜ in. (for fall); 6 to 7, 1 in. (for stand). Curve from 5 to 7, and from X to 6; 6 to 8, ¼ in. Draw line from 7 through 8 to 2. H to 6 represents the fold of collar and rever [**46**].

45. PRESSING THE KNICKERS

Pocket. One and a half in. down from waist, on line G, make 6; 6 to 7, 1⅜ in.; 6 to 8, ¾ in.; 7 to 9, the same. Draw line from 8 to 9; square two lines from 8 and 9, 5¼ in.; and connect with a straight line [**46**].

For the breast pocket the opening is 4 in. [For position see **46**.] The welt, ¾ to 1 in.

For the sleeve draft the pattern as in diagram of coat [**16**, page 1112].

Coat with Step Collar. This coat is made in the same way as the previous one with the exception of the collar.

We can therefore assume the pockets are made, and all is ready for the canvas, which must be put in loosely—¼ in. beyond the lapel.

Take a piece of linen, 7 in. long and 1 in. wide, to form the bridle or linen stay; crease it through the centre, and place the crease on the thread marks for turn over—that is, from H to X [**46**].

Baste in position, holding the bridle a little tightly, but not tightly enough to full it in any way, and place the front on the knee. Work two rows of padding beyond the crease (that is, away from the worker), pad the lapel to within ¼ in. of the edges, rolling it well over the hand. Pare the canvas away a good seam, and place the linen stay on the edge, as has been already shown, extending it 2 in. beyond the top of lapel.

Now take an extra piece of canvas or old cloth (the latter for preference), which must extend just beyond the armhole and be carried to the side seam. It must be well basted to the under canvas all round, and the front secured to the bridle. The stitches must not show through, as they remain in.

The Facing. Place the fore part on the table, lapel turned back, and press over a piece of linen. The facing is now basted in, and must be put on full round the edges of lapel, as from H to X (if this is not done the lapel will not lie flat, but curl up), and should extend ½ in. above the neck line.

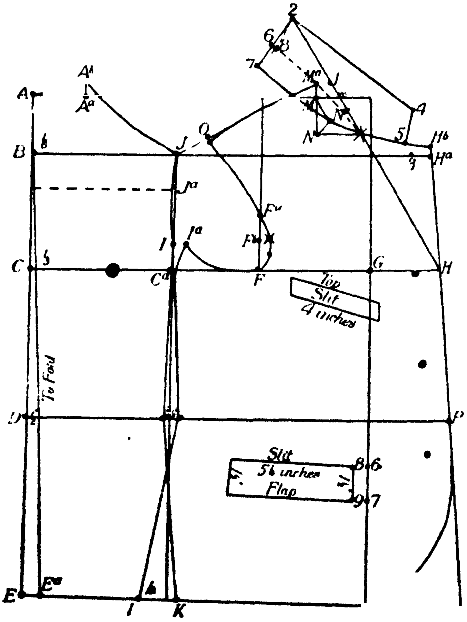
Stitch the edges, cut them even, remove the basting, turn the facing over, and work the point out nicely. Baste the edge of lapel on the right side, working the seam over ⅛ in., so that it will not show on the edge. If it shows, the effect will be spoiled. Roll the lapel over the finger, pressing the cloth a little towards the corner, and baste from top to bottom over the crease. Turn the fore part over, facing uppermost; turn the lapel back under, and place it in this position on the table. Baste the edge from lapel to the bottom, keeping the seam in ¼ in., so that it does not show on the right side. Baste down the centre of facing, taking great care not to pull the cloth back from the lapel, but rather keeping it easy at that part. Serge the edge of facing to canvas only. Nick the cloth a seam from the corner of lapel, and continue coat as shown.

After pressing the seams secure the canvas to the turning beyond the shoulder seams, stretching the canvas while doing so. Secure the cloth facing to the canvas, and insert linings.

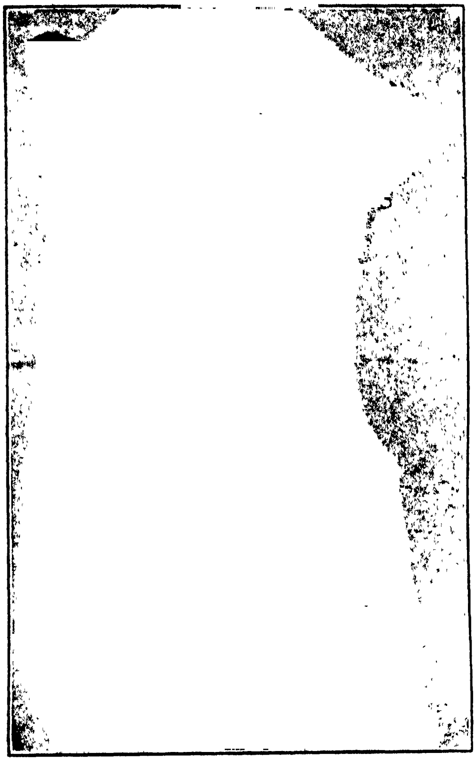
Tracing Collar. We are now ready for the collar. Trace it off on a piece of brown-paper, marking the crease (X to 6). The canvas must be on the bias, and two pieces are required, which may be cut ½ in. longer at centre of back. Join centre-back by letting one end overlap the other. Cut two pieces of cloth ½ in. larger than the collar all round. Stitch them together at the back, and press open; turn the canvas back to crease, and fit to the neck. If it is a little small, stretch it to make it fit. Place the canvas on the wrong side of collar, leaving ¼ in. margin all round, and baste through the crease.

The stand must have a few rows of stitching to make it firm, and the fall must be padded to the cloth, care being taken to have no ridges between the rows. Turn the stand back, place on the table with the latter uppermost, and press (keeping the neck "snug"—*i.e.*, well in shape and not stretched). Now cut the outside collar. This must be cut across the material in one piece, and ¾ in. larger all round—more if the material be loose or inclined to ravel. Be sure to chalk-mark the turn-over. Place the collar on the table, cloth uppermost; put on the outside collar with the wrong side uppermost, baste to collar through the centre, leaving ¼ in. over and above the edge.

Now baste the edges together from the right hand, fulling the cloth on well 1 in. on either side of the corners [see FLAP POCKET]. Stitch the edge, remove basting, turn the facing over, work the corners out well, baste round the edge from the inside, keeping the seam well under. Roll each end over the finger, pressing the cloth towards the point, and put two or three small basting stitches to keep in position [47]. Pare the canvas away, leaving ¼ in. of cloth free, from end to end. Secure the facing and canvas to the neck part, turn the coat over, wrong side uppermost; place the collar on, with the notches together and the centre of collar to centre of back; baste to the neck along the edge, and stitch or fell on the thread marks. Remove the basting, open and press the seam, and turn the coat over.



46. DRAFTING OF COAT



47. THE COLLAR

Fell the raw edge of under-collar round the neck, pulling the cloth down a little over the seam at the corners, and holding the collar well over the hand, slightly stretching the hollow of the neck. Turn the coat over; turn back the collar and lapel, place on a sleeve-board, and press over a piece of linen right round, curving the neck and keeping it "snug." Take a needle and silk, and stitch along neatly from end to end, just below the crease, to keep the collar-facing in position.

Sew a hanger on coat near the lining, and stitch twice at both ends. Place a piece of linen on the right side of collar and lapel, and give a gentle press off. The iron must be lifted up and down, not moved backwards and forwards.

Continued

Continued from page 1484

REINFORCED CONCRETE

The Advantages and History of Reinforced Concrete. Details of Construction and Formulæ. Use of Expanded Metal

By Professor HENRY ROBINSON

BOTH on the Continent and in America the combination of concrete with iron or steel has for years past been employed for different kinds of structures, but until quite recently the importance of this method of construction has not attracted the practical attention of engineers and architects in England which it deserves. Combinations of concrete with iron or steel are known by various names such as "Ferro-concrete," "Armoured Concrete," "Concrete Steel," "Fortified Concrete," etc., but the name "Reinforced Concrete" is the term now generally accepted as covering all systems.

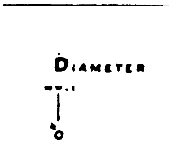
Perhaps the first use of reinforced concrete was in 1876, when M. Monier put into practice an invention for which he received a diploma at the Paris Exposition in 1878. As Monier's system became known, and the importance of his method of construction recognised, other systems sprang into existence, the outcome of various combinations of material, and at the present time some fifty exist, many evidently being brought out to avoid infringing patent rights. Some of these systems employ metal with peculiar sections. Others employ ordinary sections in peculiar positions. All, however, have the same object in view—that of placing the metal in such a position that it will take up those stresses which the concrete is least able to deal with, or which the concrete would not be able to take unaided.

The peculiar properties of reinforced concrete are still the subject of controversy, and most of the constructors or patentees rely chiefly on empirical formulæ and "specific combinations" (as they are legally termed).

The advantages of the system will be better appreciated if we give examples of the various purposes to which it has already been practically applied.

American Use. In America this "reinforced" concrete is used in the construction of office buildings of sixteen stories, also for factories, railway stations, etc., the foundations, walls, columns, girders, floors and roof forming one monolithic mass. The Visintini system (introduced from Switzerland) employs girders of the Warren type, but of armoured concrete, made separately, and resting on brackets placed on armoured concrete columns. Across these main girders are similar, but shallower, girders, laid together and forming the floor. One manufacturing establishment built in this way is 200 ft. long and 50 ft. wide, having a middle row of columns. The main girders are 24 ft. long, 25 in. deep, 12½ ft. apart, and carry beams 12 ft. long and 6 in. deep, laid closely together. The girders and beams are composed of 1 part of Portland cement, 1½ of sand, and 3½ of broken trap rock, armoured or reinforced with ½ in. steel bars. The columns are composed of 1 of cement, 2 of sand, and 4 of broken stone; they have vertical 1 in. steel rods, connected by horizontal rectangular hoops of steel Another system of concrete construction now being extensively used for residences, and for hotels, banks, and business buildings in the smaller towns, consists in the use of hollow concrete blocks instead of bricks. These blocks are made in moulding machines of various kinds, all sorts of moulds being used for ordinary blocks, lintels, sills, pillars, and architectural or ornamental shapes.

A Reinforced Concrete Reservoir. The following is a description of a design for a circular service reservoir for water supply which the writer made a few years ago, and which had to be constructed on the site of an old one that had collapsed through the subsidence of the ground caused by the removal of coal beneath it. The work was designed to be carried out by the Armoured Concrete Construction Company, of Westminster. The various calculations are given in detail to show the methods employed to determine the sections of the combined materials.



1. SECTION OF WALL

Owing to the fissured condition of the land, the calculations were based on the wall standing on the ground unsupported on either side, as shown by 1, from which it will be seen that the depth of the reservoir was 13 ft. 4 in., and its diameter 86 ft. 9 in

When the reservoir is full the maximum horizontal pressure near the bottom = Z.

Z (for a section 4 in. high) at 160 in. of water = 0·0026 ton per square inch.

$$Z = 0{\cdot}0026 \times 4 \text{ in.} \times \frac{\text{diameter}}{2} = 5{\cdot}41$$

The sectional area for the iron rods necessary to take this tensile stress is calculated on the assumption that two-thirds of the (which is taken at 6·4 tons) is not This is in order to allow for any weakness in the welded or hooked joints.

Then, sectional area of rods

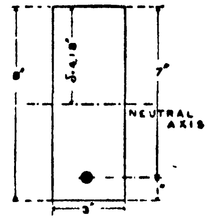
$$= Fe = \frac{5{\cdot}41}{\frac{2}{3} \times 6{\cdot}4} = 1{\cdot}27 \text{ sq. in.}$$

As the walls were arranged to be constructed with double armouring, it followed that instead of one rod of 1·27 sq. in. area, two rods of 0·625 sq. in. (or $\frac{15}{16}$ in. diameter) were used, and spaced as shown in 5. The rods for the top portion of the wall, where the pressure is not so great, are reduced to ¾ in. diameter. The vertical rods are spaced 4 in. apart, making a network having meshes 4 in. square.

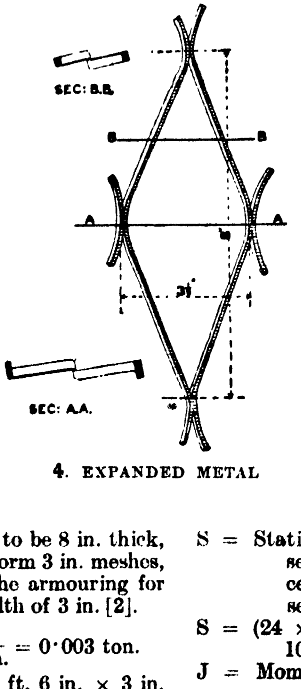
The concrete in this case was 10 in. thick at the bottom and 5 in. thick at the top of the wall, but the thickness depends entirely on the conditions of each case under consideration.

Calculations for the Floor. The floor was calculated to carry at any part an equally distributed load of 4 tons per square yard with a clear span of 6 ft. 6 in.

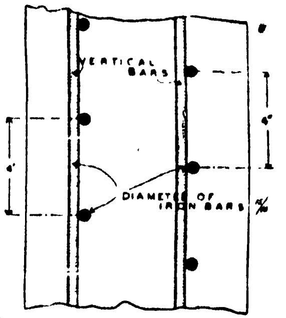
	Tons per sq. yd.
Water pressure = 0·0026 ton per square inch or	3·37
Allow for dead weight	0·63
Total	4·00



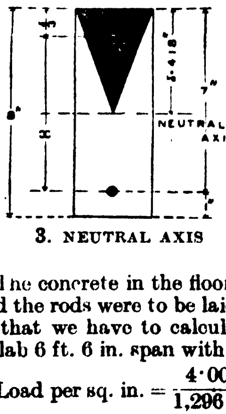
2. SECTION OF FLOORING



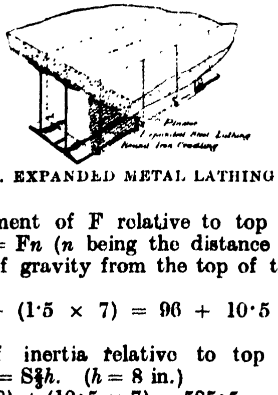
4. EXPANDED METAL



5. POSITION OF RODS IN WALL



3. NEUTRAL AXIS



6. EXPANDED METAL LATHING

The concrete in the floor was to be 8 in. thick, and the rods were to be laid to form 3 in. meshes, so that we have to calculate the armouring for a slab 6 ft. 6 in. span with a width of 3 in. [2].

$$\text{Load per sq. in.} = \frac{4\cdot00 \text{ tons}}{1{,}296 \text{ sq. in.}} = 0\cdot003 \text{ ton.}$$

Total load for 3 in. slab = 6 ft. 6 in. × 3 in. × 0·003 = 78 in. × 3 in. × 0·003 = 0·70 ton.

The slab being taken as a continuous girder,

$$M = \frac{PS}{10}.$$

$$\text{Moment of load} = \frac{0\cdot70 \times 78}{10} = 5\cdot46.$$

For a rough calculation of the sectional area of the rods the following empirical formula may be used:

$$Fe = \frac{M}{K \times \frac{3}{4}d}$$

where M = Moment of load,
K = Safe load per square inch for iron (6·4 tons),
d = Thickness of concrete.

Therefore,

$$Fe = \frac{5\cdot46}{6\cdot4 \times \frac{3}{4} \times 8} = 0\cdot14 \text{ sq. in. or } \frac{7}{16} \text{ dia.}$$

It is necessary now to determine whether in the section that has been obtained either the compressive stresses in the concrete, or the tensile stresses in the iron, will exceed their limits. The proportion of the coefficients of elasticity of concrete and iron being 10, it follows that ten times the section of iron represents the proper area of concrete, and for the increased total sectional area thus obtained the exact position of the neutral axis has to be calculated [3]. From this the maximum compressive and tensile stresses can be deduced thus:

F = Increased sectional area = 8 in. × 3 in. + 10 × 0·15 = 25·5 sq. in.

S = Static moment of F relative to top of section = Fn (n being the distance of centre of gravity from the top of the section).

$S = (24 \times \frac{8}{2}) + (1\cdot5 \times 7) = 96 + 10\cdot5 = 106\cdot5.$

J = Moment of inertia relative to top of section = $S\frac{2}{3}h$. (h = 8 in.)

$J = (96 \times \frac{2}{3} \times 8) + (10\cdot5 \times 7) = 585\cdot5.$

δ = Distance of neutral axis from top of section $= \frac{S}{F} = \frac{106\cdot5}{25\cdot5} = 4\cdot18$ in.

$J\delta$ = Moment of inertia relative to neutral axis $= J - \delta^2 F = 585\cdot5 - 4\cdot18^2 \times 25\cdot5 = 138\cdot5.$

From the following formula of Navier's the maximum compressive or tensile stress at a distance y from the neutral axis $= \gamma = \frac{yM}{J\delta}$.

7. EXPANDED METAL FOR CULVERT

the value of y in this case being, for compression 4·18, and for tension 3·82.

Thus we have:

Maximum compressive stress in concrete

$$\frac{4\cdot 18 \times 5\cdot 46}{138\cdot 5} = 0\cdot 17 \text{ ton per square inch}$$

Maximum tensile stress in concrete

$$= \frac{3\cdot 82 \times 5\cdot 46}{138\cdot 5} = 0\cdot 15 \text{ ton per square inch}$$

Assuming that the whole of the tensile stresses are taken up by the iron bar, the tensile stress Z in this bar is calculated as follows [3]:

$$Z = \frac{M}{x},$$

where

M = Moment of load,

x The distance between the centres of the tensile and compressive stresses.

The centre of the compressive stresses is situated at the distance $\delta + 3$ from the top of the section. The tensile stresses may be fairly assumed to be in the centre of the bar. Thus we have

$$x = 8 \text{ in.} - \left(\frac{\delta}{3} - 1\right)$$

$$= 8 - \frac{4\cdot 18}{3} - 1 = 5\cdot 61,$$

$$Z = \frac{M}{x} = \frac{5\cdot 46}{5\cdot 61}$$

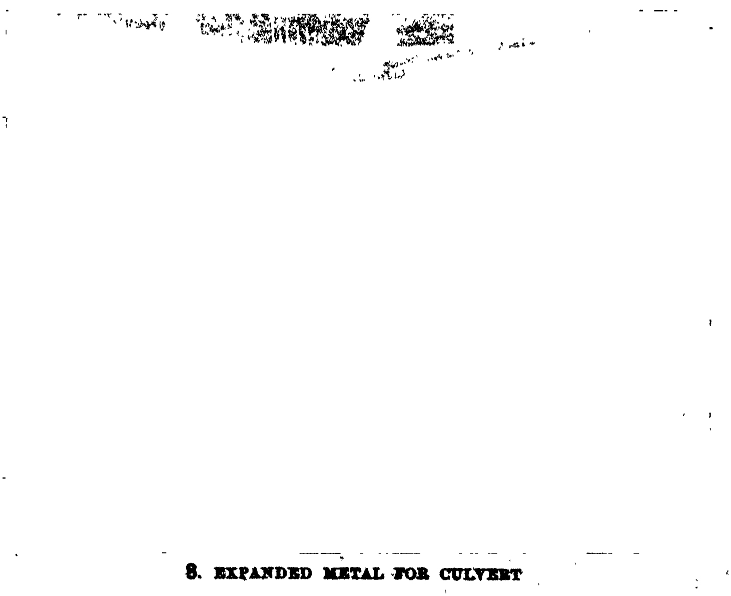
= 0·96 ton.

The sectional area of the rod being 0·15 sq. in., the tensile stress in the bar of $\frac{0\cdot 96}{0\cdot 15} = 6\cdot 4$ tons per square inch.

Concrete and Expanded Metal. The method of reinforcing concrete employed by the New Expanded Metal Company is deserving of mention. It is carried out by placing sheets of mild steel vertically on edge, and with one operation slotting and drawing out the metal to the form shown in **4**. No loss of material or weight takes place. The expansion varies between 6 to 12 times the original length of the sheet, but there is no alteration in the width.

The resistance of the sheet before being expanded is 48,000 lb. per square inch. The ultimate strength of the metal when expanded is said to be increased up to 63,000 lb. per square inch. There is a loss of elasticity in the metal which is rather advantageous, as it is not advisable to have too elastic a substance.

The formula employed by the Expanded Metal Company for concrete slabs reinforced with expanded steel is as follows:



8. EXPANDED METAL FOR CULVERT

Safe working load in cwts. per square foot

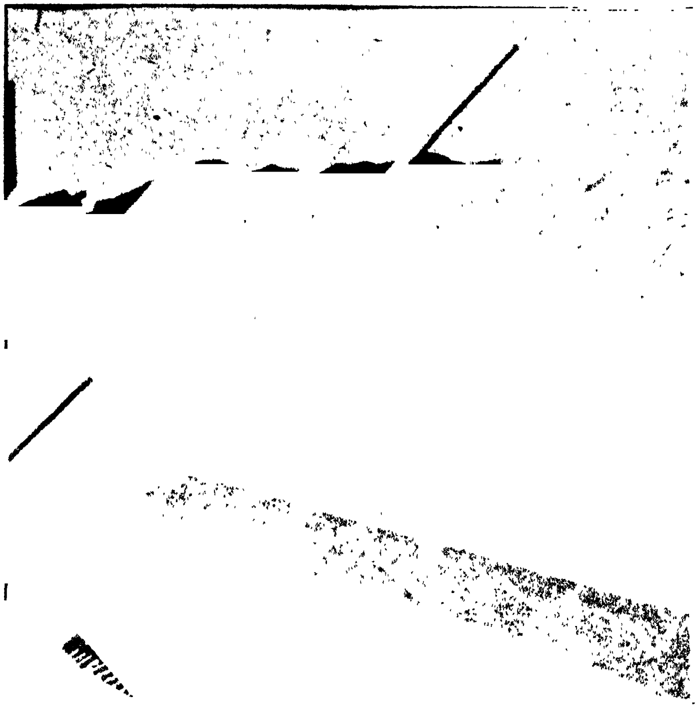
$$= \frac{6 \times t^2}{s^2},$$

where t = Thickness of slab in inches,
s = Span in feet from centre to centre of supports.

The sectional area of the expanded metal as compared with that of the concrete is in the proportion of 1 to 200.

Expanded metal is not adaptable to beams, so that where floors, etc., are being constructed on this principle the ordinary steel joists are employed. In cases where it is necessary to plaster the underside of the joists, or girders, the method of doing so is as shown in **6**.

Use in Culverts and Conduits. Figs. **7** and **8** show the construction of a culvert with expanded metal reinforcing the concrete. Fig. **9** gives details of a reinforced concrete conduit.

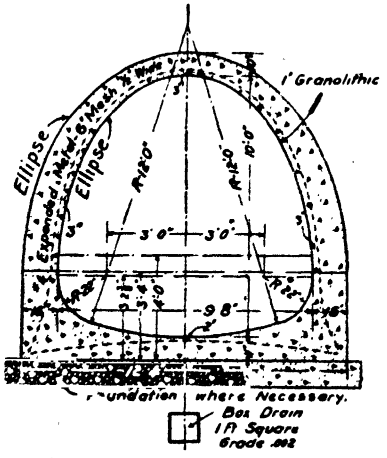


10. WEST HARTLEPOOL SEA-WALL

Figs. **10** and **11** show a retaining wall constructed at West Hartlepool. This wall, although on the sea front, was not designed to withstand heavy sea action.

Bridge Construction with Reinforced Concrete. Figs. **16** and **17** show the employment of armoured concrete on a bridge constructed by Messrs. Wayss & Freytag over the river Ybbs. Fig. **16** shows the work in progress, while **17** is a view of the bridge when completed.

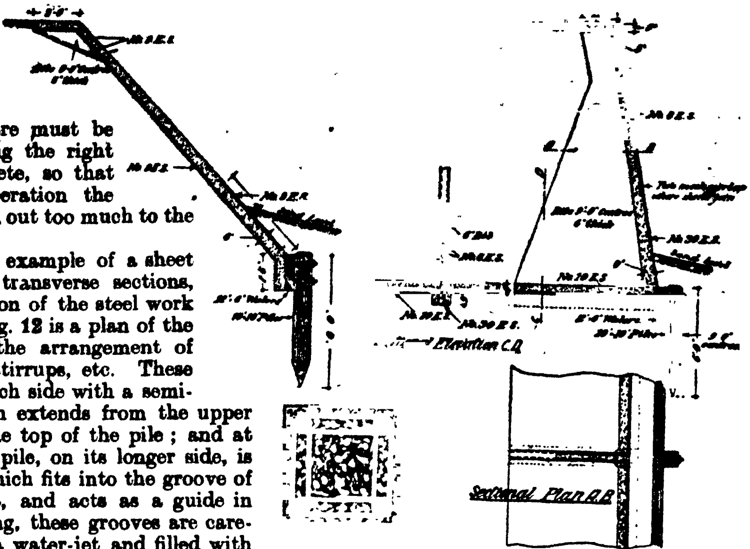
Reinforced Concrete Piles. Piles constructed of reinforced concrete have been successfully employed, and an interesting description of their uses was given by Mr. A. G. Galbraith, in a Paper at the Society of Engineers, in 1902. Their superiority to wooden piles consists in their being free from decay and attack of insects. With regard to the destruction of wooden piles by insects, the "teredo," or ship worm, has been known to destroy a pile within twelve months. It has been found that in a comparatively short time 50 per cent. of the weight of the pile has been removed. The reinforced concrete pile, however, may be considered indestructible.



9. EXPANDED METAL CONDUIT

Figs. **12**, **13**, and **14** illustrate the piles that were used in the case referred to. They were constructed on the Hennebique system. Fig. **15** shows the steel reinforcement ready for moulding with concrete as follows:

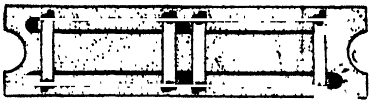
The piles are constructed in vertical timber moulds supported by frames, the inner section of the mould corresponding to the size and shape of each pile. The working face of the mould is left open, care being first taken to see that everything is perfectly plumb. The steel shoe is then inserted in the bottom of the mould, with its upper ends turned over inwardly to form a key to the concrete. The vertical rods are then placed in position, about an inch below the surface of the concrete, and connected together with distance pieces dropped from the top as required. Concreting is then commenced and the working face of the moulds is gradually closed with shuttering fixed about every 6 in. in height by the workman as he proceeds with the punning. After about 38 hours the concrete is sufficiently set for the moulds to be stripped, and the piles are allowed to remain from 28 to 40 days to dry preparatory to driving.



11. DETAIL OF WEST HARTLEPOOL SEA-WALL

It is sometimes more economical and convenient to make the piles in horizontal moulds, but in that case the greatest care must be observed in obtaining the right consistency of concrete, so that in the punning operation the cement be not worked out too much to the upper surface.

Fig. 13 is a typical example of a sheet pile in elevation and transverse sections, showing the disposition of the steel work and drifted shoe. Fig. 12 is a plan of the same pile, showing the arrangement of the distance pieces, stirrups, etc. These piles are fitted on each side with a semicircular groove which extends from the upper end of the shoe to the top of the pile ; and at the lower end of the pile, on its longer side, is fixed a metal spur which fits into the groove of the pile preceding it, and acts as a guide in driving. After driving, these grooves are carefully cleaned out by a water-jet and filled with cement grout, forming a solid watertight joint between the piling. These piles are made in lengths of 46 ft. and 48 ft., and have all the resiliency and elasticity of timber piles. As an instance of this, a 14 in. by 14 in. pile, 43 ft. long, suspended in the middle, will bear a deflection of from 3½ in. to 4 in. and, unlike timber piles, they can be easily lengthened and joined to the adjacent work.



12. FERRO-CONCRETE SHEETING PILE

The design of the pile is based on a calculation of the force to which it will be subject in the operation of driving, and the following formula enables this to be determined.

Let

W = The load,

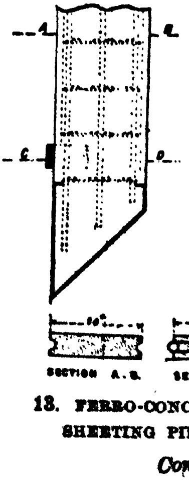
Q = Weight of monkey or ram,

f = Fall of monkey.

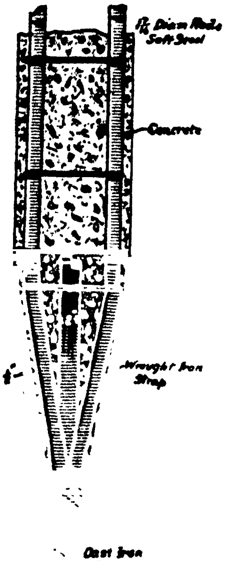
Then

$$W = Q \times 8\sqrt{f}. \quad (1)$$

Dr. Ritter's formula is generally used to ascertain the supporting power of piles after driving.



13. FERRO-CONCRETE SHEETING PILE



14. FERRO-CONCRETE PILE

W = Load in pounds,

Q = Weight of monkey,

q = Weight of pile in pounds,

h = Height of fall of monkey,

e = Final penetration in inches.

Then

$$W = \frac{h^2}{e} \times \frac{Q^2}{Q+q} + Q + q \quad . \quad . \quad (2)$$

The value of e varies from 0·25 to 0·10 in., according to the strata into which the pile is being driven. The former value suffices under ordinary circumstances. On the value of W being obtained, it must be reduced to the safe bearing load, with an allowance of 10 as a factor of safety.

Pile Driving. Reinforced concrete piles can be driven either by hydraulic pressure or by the ordinary pile-driver. The best results, however, seem to be obtained by employing a heavy monkey with a short drop. A helmet should be placed on the pile with a space between the head of the pile, and the helmet filled with sawdust.

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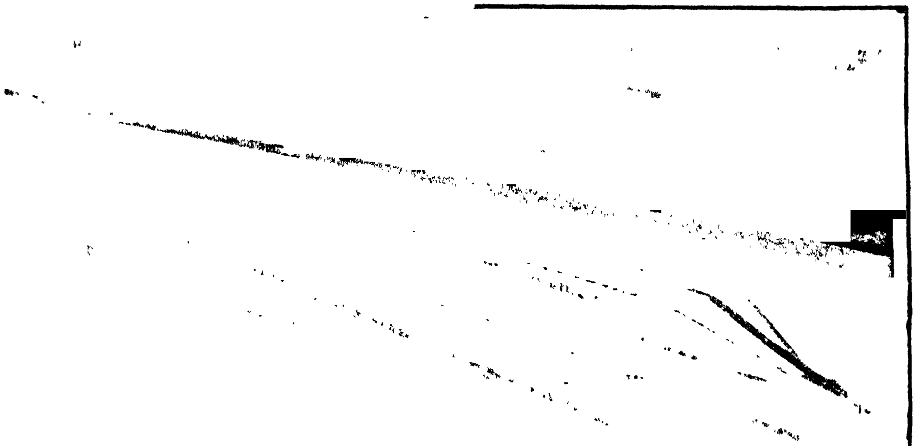
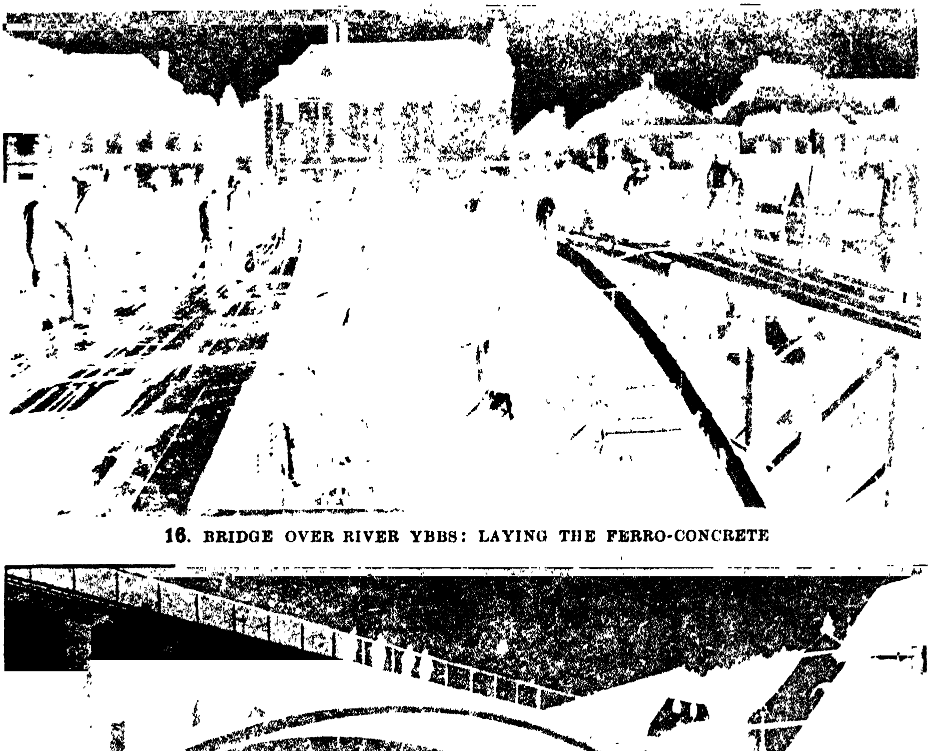
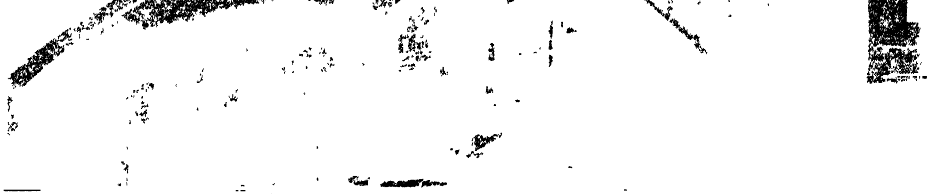


15. FERRO-CONCRETE PILE BEFORE MOULDING



16. BRIDGE OVER RIVER YBBS: LAYING THE FERRO-CONCRETE



17. BRIDGE OVER RIVER YBBS: COMPLETED

Group 13

GEOGRAPHY

11

Continued from page 1267

THE SCANDINAVIAN KINGDOMS

Leading Characteristics of Norway and Sweden. The Midnight Sun. Sweden Contrasted with Norway. Denmark and Iceland

By Dr. A. J. HERBERTSON and F. D. HERBERTSON, B.A.

NORWAY

PARALLEL to our shores, 400 or 500 miles to the east, lie the Scandinavian kingdoms of Norway and Sweden (forming the peninsula of Scandinavia), and Denmark, formed of the peninsula of Jutland, running north from the mainland of Central Europe, and of many islands. They almost separate the North Sea from the Baltic Sea, which is entered from the west by the Skagerrack, Kattegat, and Sound, as already described. Our shores early offered a prize to the pirates of these northern lands, who also occupied the valley of the Seine in France, and, becoming known as Normans, conquered our country in 1066. Our own blood, therefore, is largely mixed with Scandinavian.

Characteristics of Norway. Norway (124,000 sq. miles) occupies the western and steeper slope of the Scandinavian plateau, rising to over 8,000 ft. Except on the lower slopes, it is a treeless moorland, covered with heather, lichens, or reindeer moss. The peaks rise above the snow-line, and the higher valleys are filled with glaciers. The rivers, which often form magnificent waterfalls, descend as swift torrents to the sea. The lower ends of the valleys have been drowned, forming a fringe of rocky islands called the Skerry Guard, the dangerous currents between which gave rise to stories of maelstroms and whirlpools, and fjords [65, p. 980] like those of the Scottish Highlands, but far longer, and enclosed between mountain walls thousands of feet high. These fjords are visited by thousands of tourists every year. The Sogne Fjord, over 100 miles long, one of the most beautiful, has been thus described: "At one moment the boat is beneath a huge cliff that seems to block the narrow channel; at another she is sailing over a clear space, out of which open a number of rocky side fjords. At one moment the view is limited to a few hundred yards of water, bounded on every hand by stupendous precipices; at another the eye ranges up a beautiful valley, or through some depression in the fjord wall catches distant sunlit peeps of glacier or of mountain outlines."

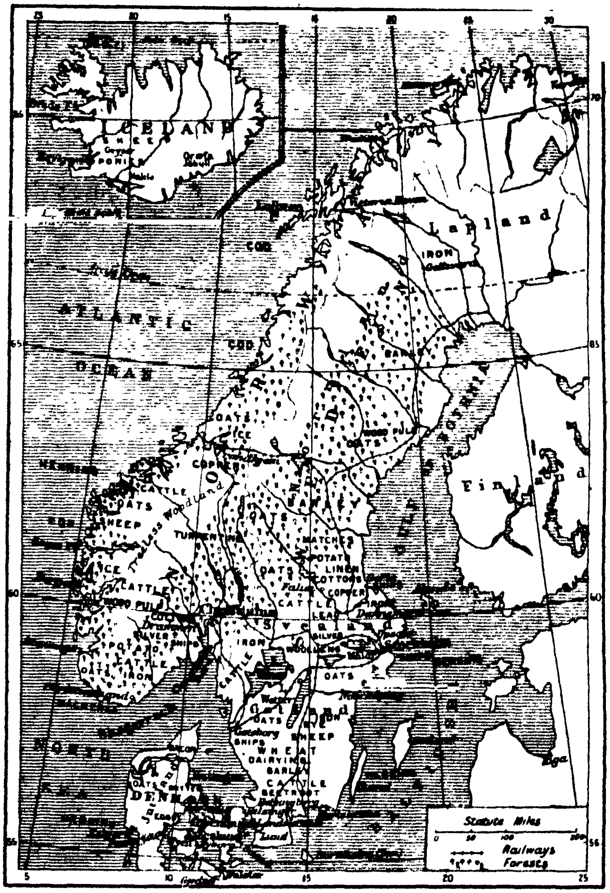
Many waterfalls leap over the fjord walls, adding to the beauty of the scene. High up on the cliffs are seen little farms, where it is said both animals and children are tethered.

Climate. Norway extends from the latitude of Aberdeen to just within the Arctic Circle, giving a considerable difference of temperature between the north and south. Its western shores are washed by the Atlantic, and its prevailing winds, like our own, are south-westerly. As in our own land, these make the winter much milder than it would otherwise be. Norway is a country of considerable elevation, and the high altitude tends to lower the temperature; but the waters of the surrounding seas and the winds blowing over them are warmed by the surface drift from the Gulf Stream, and its ports are therefore ice-free in winter. The climate of the south resembles that of Northern Scotland, with mild winters and cool summers, but in the high interior, and as we go north, the winter becomes very severe, and the land is buried in snow for many weeks. These, however, are almost uninhabited regions, and on the coast, where most of the people live, the winter is less severe than in many more southern parts of Europe. The summer is nowhere hot. Rain, as we should expect, is abundant, especially in winter, when the Atlantic winds have their greatest force.

Land of the Midnight Sun. In our own country we know how late the sun rises in winter, and how early it sets. In Norway, which lies almost wholly north of our islands, this is much more marked. The winter days are everywhere short, and as we go north they are reduced to little more than an hour or two of twilight. The compensation comes in summer, when each day the sun rises higher and remains longer above the horizon. Night becomes merely a short twilight, and in the far north the splendid spectacle of the midnight sun is seen. A traveller writes: "After leaving Hammerfest, we were all on deck to witness sunset and sunrise, if thus it can be termed. It was about 11 p.m. The effect of the sunlight on the headlands was wonderfully beautiful, for as the sun sank lower their tints kept changing, till at last they seemed to be bathed in a vermilion hue. It was now midnight. In a few minutes we noticed the sun gradually rising higher and higher, and now the colours were of a totally different hue. Day had succeeded night almost imperceptibly." With almost continuous sunlight, vegetation comes on as if by magic, and sowing and reaping succeed each other in a few weeks.

A Nation of Seamen. In the high interior the forests of the lower slopes make the cutting of timber and the gathering of turpentine important. Above the tree-line are mountain pastures, to which the cattle are driven in summer. Only the coast is thickly peopled. As in the West Highlands of Scotland, farming is eked out by fishing, which is extremely important. The Norwegians are a nation of seamen. The forest timber has always made the building of boats an easy matter, and the fjords are natural roads from the desolate interior to the sea, with its teeming waters and rich lands beyond. Anciently pirates, the Norwegians now do an immense carrying trade in all parts of the world. One of the great fishing centres is the Lofoden Islands, in the north, where millions of codfish are caught and dried annually; then the reeking livers are stewed in huge boilers for cod-liver oil. The season begins in January, and lasts till April. For the next two months the fish are left to dry in the summer sun, and the fishing fleet returns for the spoil in June. The whale and seal fisheries are also important. In a word, it is to the sea, not to the land, that the Norwegian looks for a living. Of the land three-fourths is unproductive, over one-fifth forest, and less than one-thirty-third cultivated.

Towns of Norway. In such a country the towns are, of course, all on the coast. In the south, on Christiania Fjord, is Christiania, the capital, at the end of an ocean avenue fringed with pines and walled with mountains. Farther east, the Glommen, the longest river of Norway, flows to the Skagerrack. Look out on the map Drammen, Stavanger, Bergen, Christiansand, the old city of Trondhjem, Narvik, formerly Victoria Haven, the terminus of a line across the mountains from Gellivara in Sweden, Hammerfest, and Vardö, all fishing ports, finely situated on fjords.



79, SCANDINAVIAN KINGDOMS, SHOWING CHIEF INDUSTRIES

SWEDEN

Sweden (nearly 173,000 sq. miles) is the gentle eastern slope of the Scandinavian plateau. In the north the province of Norrland occupies half of the country. It is "a land of very short summers and very long winters, of high mountains, and great rivers which run in almost parallel lines to the sea, forming navigable waterways to the coast 200 and 300 miles long, a land of great primeval forests and swampy wildernesses, of vast timber and mining industries." Svealand, the midland province, is "the region of great lakes and smiling pasture lands, of well-tilled fields and well-to-do peasant homesteads, of prosperous towns and flourishing industrial enterprises." Götland, in the south, is the richest part of Sweden. "The ports along its seaboard are only rivalled by the capital, which dominates the midlands. Rich agricultural lands and teeming factories are the principal sources of Sweden's agricultural and industrial wealth."

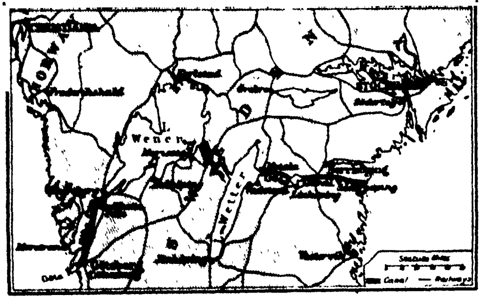
Contrasted with Norway. Here, evidently, is a land very different from that on the opposite slope of the mountains, in which a richer and more varied life is possible. Unlike the Norwegian, the Swede may hope to win a living from the land, with its triple gifts of corn lands, forest, and minerals. The highlands of Norway intercept the mild, rainy winds from the Atlantic, just as the western highlands do in Britain. There is the same contrast between the wet, mild, west Norway and the more extreme and drier east Sweden. In winter the Swedish ports are closed by ice, and a difficult line has been carried across the mountains to reach Narvik, the ice-free port for the northern iron mines in winter.

As in Norway, the summers are short, and almost continuously light, while the winters are long and dark. They are, however, more severe than in Norway. The duration of winter varies considerably. In Norrland ice and snow last about 200 days, against 150 in Central Sweden and 115 in the south. In the south the ice on river and lake breaks up in April, but further north not till May or June, according to latitude and elevation.

Resources of Sweden. These are threefold. In the flat south, wheat, barley, rye, and oats are grown, and much beetroot for the numerous sugar factories. In the undulating midlands innumerable farms are found in the forest clearings, the cattle being driven in summer up to the higher, richer pastures.

In the north neither the mountainous country nor the climate suits agriculture, though a little is carried on as far north as the Arctic Circle. This is the forest district, which supplies Sweden with her leading export—timber in various forms. Much is sawn in the forest, in mills turned by the innumerable streams. It may then be converted—by water-power, of course—into door or window frames, while the shorter lengths are made into matches, or wood-pulp, out of which much paper is now manufactured. In all these forms the forest helps to enrich Sweden. Mining is also extremely important; Swedish iron in particular, which is most abundant round Gellivara in Lapland and Dannemora in the centre, is of excellent quality and in great demand. Copper is mined at Falun, and there are other useful metals. Coal is scarce.

How the People Live. Outside the towns the Swede is a farmer, a forest worker, or a miner. In the towns he is a clever, industrious artisan, whose industries are rapidly growing. In the remoter districts, where communication between farm and town is difficult, the farmer must be farrier, blacksmith, wheelwright, etc., while his womenfolk spin and weave, and are the tailors of the family. In the mountain dales the picturesque old dresses are still worn, and life is lived very simply and frugally. The towns are attracting people from the country districts, and there are signs that Sweden is slowly changing to an industrial country. For such a career she has many advantages. A notable one is the excellent water communication. The great lakes are like inland seas. Wener Lake covers over 2,000 square miles. Lake Wetter is nearly 750 square miles, and Lake Mälar 500 square miles. Many canals have been cut to unite these and smaller lakes. The most important is the Göta Canal, from Göteborg (Gothenburg), the chief port, to Stockholm, the capital, by way of Lakes Wener and Mälar. As in Norway, most of the towns are on the coast. Göteborg, Helsingborg, Landskrona, Malmö, Karlskrona (the naval station), Norrköping, and Stockholm (the capital) may be looked out on the map. Of inland towns the most important are the universities of Lund and Upsala. Stockholm, built on islands connected by many bridges, is often called the Venice of the North. With its lakes and pinewoods, its hills crowned by palaces and churches, and its many fine buildings, it is one of the most picturesque capitals in Europe.



80. THE GÖTA CANAL

DENMARK

Denmark consists of the peninsula of Jutland on the mainland, the large islands of Fyen (Fünen) and Sealand, and many smaller ones. Look out these and the channels between on a map. Including the Faroe Islands and Iceland, its area is about 15,000 square miles. Neither mainland nor islands have hills over 600 ft. high. The scenery owes its charm to the contrast between the cultivated shores and the winding straits. Jutland has low, sandy shores with many lagoons on the west coast, and a somewhat higher shore, with better harbours, on the east. After the primeval beech-forests disappeared, it passed into boggy, treeless moorland, almost impossible to cultivate. Within the last century much has been converted into excellent meadow or agricultural land by draining, and by planting trees on the western or windward side. Roads and railways now penetrate prosperous districts which, in the lifetime of their inhabitants, were inaccessible and houseless moorlands. Four-fifths of the country is now productive.

Denmark is in the latitude of Southern Scotland, and has a similar climate, with rather colder winters and warmer summers. There is sufficient rain to keep the meadows green. The Baltic is frozen in winter, and the Sound and other channels occasionally blocked with ice.

Danish Industry. The Dane is a model farmer and dairyman. By promoting education and using the best scientific methods, he has transformed a poor country into a prosperous one. Danish dairy produce, butter, bacon, and eggs, are famous for their excellent quality. Many dairy farmers work on the co-operative principle, which gives uniformity of quality at minimum cost. One large co-operative dairy handles the milk of over 6,000 cows daily. The chief agricultural crops are barley, rye, and sugar beet, with which are connected the industries of distilling and sugar-making. Denmark is a land of seas and islands, and most towns are naturally on the coast. To communicate between island and island, the trains are run on to ferry steamers. Look out on the map Esbjerg on the west coast of Jutland, Aarhuus and Fredericia on the east, Nyborg on Fyen, Gjedser in the south of Falster, and Elsinore, or Helsingor, and Copenhagen on the Sound. Copenhagen (Kjöbenhavn, meaning Merchants' Haven), the capital, is admirably situated for trade, at the entrance to the Baltic. Seen from the sea, its harbours crowded with shipping, and its spires outlined against the sky, it is extremely picturesque.

The Faroes, or Sheep Islands. Few of these are inhabited. Fishing and the keeping of sheep and ponies are the chief occupations.

Iceland. Iceland is a land of mountains, snow fields, volcanoes, geysers, long, hard winters, and short, light summers. Sheep and ponies are fed, and the men go to the Arctic fisheries. The fine scenery, including the active volcano of Hekla, attracts tourists in summer. The capital is Reykjavik, in the south-west.

Continued

THE SCIENCE OF HEAT

Sensations of Heat untrustworthy. Temperature and its Measurement. The Various Thermometric Scales

Continued from page 1376

By Dr. C. W. SALEEBY

THE epoch-making development of the physical sciences during the first five years of this century has rendered the task of the writer an exceedingly difficult one, since previous experience and custom can no longer afford any guide as to the proportions, and scarcely any as to the arrangement, of the various parts of his subject. Whether in writing a text-book on physics, or in arranging a series of text-books on the various branches of the science, the same difficulty is encountered. The customary arrangement was simple enough ; matter was defined in half a dozen words, motion in a few more, dynamics and the properties of matter were dealt with, and then there remained heat, sound, light, and magnetism and electricity. But the new theory of matter, to which we have made various allusions, has profoundly altered our whole conception of the subject. It looks nowadays as if electricity had, potentially at least, swallowed the whole of the rest of our subject, and to relegate it to a final section of a course of physics would be absurd. Fortunately, that has not been necessary in the present instance. But the new theory of matter has thrown more and more stress upon our conception of energy, to which we have already referred, and has still further accentuated the importance of that conception of the conservation of energy which we have called the greatest fact of physics.

Heat. In order fully to appreciate this stupendous truth, it is necessary first, however, that we turn our attention to the science of heat, the study of which was all-important in enabling physicists to found this great generalisation. Our present purpose, then, is to discuss what is known of heat—a subject to which we have already been introduced in considering the kinetic theory of gases—thereafter to devote ourselves to the study of the conservation of energy, and then to proceed to consider sound and light. Finally, we propose, if possible, to consider the magnificent work of Prof. J. J. Thomson, of Cambridge, and the new theory of matter of which he is the chief exponent. But whether we shall be able to do this depends upon the degree of completeness which that theory may attain within the course of two or three months after writing these words.

Our Untrustworthy Sensations. By way of a preliminary to our study of heat, we must first of all rid ourselves of the confusion into which our own sensations lead us. When we speak or think of heat, there is always involved an idea derived from a group of sensations with which we are all familiar ; and so the first thing we must do is to distinguish between what psychologists call the *subjective* and *objective* aspects of our study. Subjectively, we are familiar with sensations of heat and of cold, but directly we attempt to analyse the facts we observe that these sensations are in ourselves, and are due to external causes, which can be sharply distinguished from the sensations directly we remember that the same external cause may appear hot to one hand and cold to another. This may easily be proved. If you hold one hand in very cold water for a few minutes, and the other at the same time in very hot water, and then plunge the two hands into a basin of lukewarm water, one and the same objective cause will excite a sense of heat in the one hand and of cold in the other. This simple experiment suffices to demonstrate that it will not do to mix up psychology and physics in our discussion of heat. The psychologist, of course, is immensely interested to discover that the lukewarm water appears warm to the cold hand and cold to the hot hand. This to him is an instance of the fact called the *relativity of sensations*. But our present concern, as students of physics, is not with the sensations at all, but with the external objects or facts that cause them—that is to say, we are dealing with heat as an objective thing, and it would be all one to us if our bodily organisation was altered, so that, as might quite well be, heat were audible or visible.

The Poker and the Coat. But another trick which our sensations play us will serve to teach us an important fact. You pick up the poker on a cold morning, and it feels cold ; you transfer your hand to your coat and it feels warm. Yet both are probably at the same temperature. A suitable thermometer or heat measurer would contradict the opinion of your hand. The explanation lies in the fact that, as we shall see, different bodies vary widely in their power of conducting heat. The wool of your coat is a bad conductor ; it removes little heat from your hand, and so does not give you an impression of cold. The metal poker, however, which is at the same temperature as your coat (or, indeed, being near the fire, may be hotter), has the physical property of conducting heat very well. So much heat does it conduct away from your hand that the sensitive nerves appreciate the loss, and you declare the poker to be cold. Thus our senses at least can give us some idea of what is meant by the conduction of heat.

But now we dismiss the psychological aspect of the subject, and must conceive of heat as an external fact, the character of which is not in the smallest conceivable degree indicated by our sensations. As we have hinted, it would need but a small change in our construction for music to feel hot or cold, and for heat to be audible. What, then, is that external thing which causes these sensations, but to the nature of which none of our sensations can be regarded as a guide? That is the most interesting question of all, and the answer to it has been hinted at in a previous section, but we must postpone its full consideration until we have studied the observed facts of heat, and thereafter we shall be able to conceive of heat as a mode of motion, and to understand its relation to the law of the conservation of energy.

Temperature. We have already used the word temperature, and it is now time to define it. When one thing is hotter than another—that is to say, when it is really hotter, not when it merely feels hotter—we say that it is at a higher temperature, and we measure the difference of temperature by means of the thermometer. But when we say that one thing is hotter than another, can we translate the statement into other terms? We will assume—as we have every right to assume—that heat is an external thing, or entity, to use a clumsy word, no matter what its nature may be. Now, are we not entitled to say that when one object is hotter than another, it contains more of that thing called heat? This would appear to be a reasonable interpretation of differences in temperature, but it is almost entirely erroneous. The temperature of a body is not a fact that depends upon the amount of heat that it contains, and can never be used—except under conditions defined below—as an index or guide to the amount of heat in any body. What, then, is temperature? We can best define it by observing its consequences. When one thing is hotter than another, the observed fact is, that the hotter body tends to communicate part of its heat to the colder, so that the two tend to approximate to the same temperature. It does not at all follow that there is more heat in the hotter body than in the colder. In the first place, the hotter body may be very small and contain little matter; whereas the cold body may be very large and contain a quantity of matter; as, for instance, when you dip your finger in the ocean. There is immeasurably more heat in the ocean than in your finger. Nevertheless, your finger is hotter, and so the heat flows from it into the surrounding water, as your sensations tell you.

Measuring Heat. The only way, then, in which to define temperature is to compare it to the idea of level in liquids. We know that, quite apart from the amount of water in question, if we join two vessels or reservoirs containing water, the one being at a higher level than the other, the water will certainly flow from the higher to the lower. If they are at the same level, the water will flow in neither direction, though the difference in the amount of water in the two reservoirs may be as great as the difference in the amount of heat in the case of your finger and the ocean. Therefore, we must define temperature as that state of a body which determines its power to communicate heat to or receive heat from another body. And the way to understand temperature is to compare it to level in the case of liquids.

Amount of Heat. But, of course, we must not think that temperature has no relation to the amount of heat in a body. If we take a fixed quantity by weight—that is to say, more strictly speaking, a fixed mass of a given substance—then the temperature of that mass will be an index to the amount of heat it contains. The more heat we put into it, the hotter it will become. So far as differences in mass are concerned, it is evident that temperature and amount of heat do not vary together. There will plainly be more heat in a ton of lead at 30° C. than in a pound of lead at 31° C. But the remarkable fact is that different kinds of matter vary profoundly in the amount of heat they contain while exhibiting the same temperature. If, for instance, we take equal masses of water and of mercury, starting with both at the same temperature, and proceed to raise them both to the same extent, say 10° C, we find that we actually require to put about 30 times more heat into the water than into the mercury. Yet at the end of the process they are both at the same temperature, both having started at the same temperature, and we are dealing with an equal quantity of matter in each case. The difference between the water and the mercury is expressed by the term *specific heat*, and we shall afterwards have to consider it very carefully.

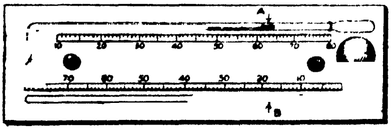
The Thermometer. The thermometer is an instrument which enables us to measure temperature, but we now understand that it does not enable us to measure *amount of heat* except by the comparison of the various temperatures of a given mass of a given substance. In the most familiar kind of thermometer, the temperature is measured by the expansion and contraction of mercury. This substance, like nearly all others, expands when it is heated and contracts when it is cooled. The mercury thermometer consists of a fine, hair-like tube with a bulb at one end, the bulb and part of the tube being filled with mercury. When the thermometer is made, the mercury is boiled in the tube so as to carry away all the air, and then the upper end of the tube is sealed. The smaller the tube, the more sensitive is the thermometer, the most sensitive kind of thermometer with which most people are familiar being the clinical thermometer. Now, in order to compare one temperature with another, it is necessary to have some sort of scale, and there are many such in existence. Here we may mention three, with the preliminary statement that they are all arbitrary and bad. Until quite recently the choice between them was merely one of convenience; but, as we shall afterwards see, they may now all be superseded, since we are in possession of a scale of temperature which depends, not upon the arbitrary selection of any substance such as water or mercury, but upon our understanding of the natural lowest limit of possible temperature. The most familiar and oldest scale is that invented by Fahrenheit (1686-1736). He did his best to obtain the lowest temperature possible, which was that of a mixture of pounded ice and salt. He called this temperature 0°, and the temperature of water boiling at ordinary pressure 212°, the freezing point of water on this scale being 32°. Fahrenheit rendered great services to physics, and honour is due to his memory, but at the present day his scale can claim no advantages whatever, in spite of the fact that it is still constantly used in this country, though abandoned elsewhere.

The Centigrade scale, which has many advantages over that of Fahrenheit, is so named because the interval between the freezing point and the boiling point of water is divided into a hundred degrees. According to this scale, the zero is the freezing point of water and 100 is its boiling point. This scale is not very much younger than Fahrenheit's, and is now universally used in science, and for all other purposes as well, in France and many other countries. It may be adapted, as we shall see, for the purposes of the *absolute scale of temperature*, which has superseded all the others in modern scientific inquiry.

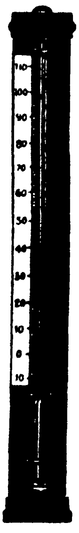
Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
—17·7	0	7	44·6	31	87·8	55	131	78	172·4
—16	3·2	8	46·4	32	89·6	56	132·8	79	174·2
—15	5	9	48·2	33	91·4	57	134·6	80	176
—14	6·8	10	50	34	93·2	58	136·4	81	177·8
—13	8·6	11	51·8	35	95	59	138·2	82	179·6
—12	10·4	12	53·6	36	96·8	60	140	83	181·4
—11	12·2	13	55·4	37	98·6	61	141·8	84	183·2
—10	14	14	57·2	38	100·4	62	143·6	85	185
— 9	15·8	15	59	39	102·2	63	145·4	86	186·8
— 8	17·6	16	60·8	40	104	64	147·2	87	188·6
— 7	19·4	17	62·6	41	105·8	65	149	88	190·4
— 6	21·2	18	64·4	42	107·6	66	150·8	89	192·2
— 5	23	19	66·2	43	109·4	67	152·6	90	194
— 4	24·8	20	68	44	111·2	68	154·4	91	195·8
— 3	26·6	21	69·8	45	113	69	156·2	92	197·6
— 2	28·4	22	71·6	46	114·8	70	158	93	199·4
— 1	30·2	23	73·4	47	116·6	71	159·8	94	201·2
0	32	24	75·2	48	118·4	72	161·6	95	203
1	33·8	25	77	49	120·2	73	163·4	96	204·8
2	35·6	26	78·8	50	122	74	165·2	97	206·6
3	37·4	27	80·6	51	123·8	75	167	98	208·4
4	39·2	28	82·4	52	125·6	76	168·8	99	210·2
5	41	29	84·2	53	127·4	77	170·6	100	212
6	42·8	30	86	54	129·2				

The Réaumur scale, invented by Réaumur (1683-1757), has been largely used in Germany. It agrees with the Centigrade in that its zero is the freezing point of water, but the interval between this and the boiling point of water is divided into eighty degrees instead of one hundred.

Conversion of the Scales. Until the Fahrenheit and Réaumur scales go completely out of use, as they sooner or later certainly must, it is occasionally necessary for convenience to convert a figure of one scale into the corresponding figure of another. This, of course, is a mere matter of arithmetic, no physical truth being involved, and so we need give the methods only very briefly. In the first place, notice that 5° Centigrade is the equivalent of 9° Fahrenheit, while either of these is equivalent to 4° Réaumur. Supposing one desires to convert a Fahrenheit statement into a Centigrade, it is necessary, first of all, to deduct 32, then to multiply the result by five, and then divide by nine. In order to convert it into degrees Réaumur, it is similarly necessary, and for equally obvious reasons, to deduct 32, the result being multiplied by four (instead of five as in the last case) and divided by nine. On the contrary, if one require to convert degrees Centigrade into the Fahrenheit scale, it is necessary to multiply by nine, divide by five, and add 32 to the result; while if one is converting degrees Réaumur, the process is exactly the same, except, of course, that one divides by four instead of five. But surely any reader could infer the necessary means of these conversions, once he had given him the facts of the equivalence of 5°, 4°, and 9° on the Centigrade, Reaumur, and Fahrenheit scales, and the fact that the Fahrenheit 32 is equivalent to the zero on the other two.



MAXIMUM AND MINIMUM THERMOMETERS
A. Maximum Index
B. Minimum Index



THERMOMETER

For convenience of reference we append a table prepared by Messrs. Negretti and Zambra showing the Fahrenheit equivalents of the Centigrade scale from Fahrenheit zero to the boiling point of water.

Maximum and Minimum Thermometers. So far as the thermometer is concerned, the particular scale that is used is of small importance. But sometimes it is of convenience to have some arrangement by which the highest or lowest points of temperature recorded may be indicated in such a way that anyone coming afterwards may see what they were. For instance, a small index of iron or glass may be placed inside the thermometer, so that it is pushed up by the advancing [illegible] but is left behind when the m[illegible] the index be made of iron it [illegible] n again by means of a small magnet. [illegible] nimum thermometer is filled with alcoh[illegible] stead of mercury, and as the alcohol falls it pulls the index down with it in virtue of surface tension. When the temperature rises the alcohol flows past the index. If two such thermometers be mounted on one board, we can see at a moment what were the limits of the variation of temperature. Another form of the maximum thermometer is the clinical thermometer, to which we have already referred. It contains no index, but at one point the tube is very much constricted, so that, when the thermometer is removed from the patient, the cohesion of the mercury is not enough to keep it together at this point; hence, the column of mercury breaks, and the highest point recorded by the mercury is retained. In order to obtain a fresh reading, it is, of course, necessary to re-establish the continuity of the mercury, and this may be done by jerking the thermometer so that part of the broken column flows past the narrowed place and rejoins the rest.

CLINICAL THERMOMETER

A Better Thermometer. Now, it is an easy matter to agree on a scale of temperature and to mark its divisions upon the glass tube, but how are we to be certain that the mercury, or, indeed, any other liquid that may be employed, such as alcohol, expands in a regular fashion? Provided that it does so, equal elongations of the column will certainly indicate equal differences of temperature. But when we come to look into the matter we find that liquids do not follow this simple rule, and so none of our ordinary thermometers can be regarded as absolutely accurate. If, however, instead of taking a liquid we take a gas, we find not only that any gas expands regularly in proportion to temperature, but also that the various gases agree with one another in this respect and can safely be compared. Hence we have the air thermometer, which depends upon the fact that the volume of a given quantity of gas increases uniformly as the temperature rises, provided the pressure be constant, in accordance with Boyle's law. This is true of gases, liquids, and solids. But gases are much more satisfactory to study, because not only is their expansion much more marked, but they expand with absolute regularity, and the ratio of expansion is almost the same in the case of all gases. The law of the expansion of gases is known by various names which do not matter, but it is of the utmost importance. The volume of a gas increases for each degree of rise in temperature by a constant fraction of its volume at freezing point, this fraction being $\frac{1}{273}$ for the Centigrade degree (it is assumed, of course, that the pressure remains constant).

The Absolute Air Thermometer. Now, instead of spending space upon the ordinary air thermometers, we may pass at once to what is called the *absolute air thermometer.* It consists of a long glass tube closed at one end and containing a long column of air which is closed by a drop of mercury. This behaves as any air thermometer would do, the expansion and contraction of the air in the tube changing the position of the drop of mercury. This thermometer is graduated on the absolute scale, in correspondence with the law already quoted. The freezing point of water, instead of being called 0° as it is in the Centigrade scale, is marked 273° C. absolute, and the boiling point, instead of being marked 100, is marked 373° C. absolute. Its zero is the *absolute zero* [see below]—that is to say, while we retain the size of the Centigrade degree, we alter the names in accordance with the theory that the fraction $\frac{1}{273}$ is of real significance. If, now, we consider the case of the air in this thermometer, we are able to lay down the proposition that, the pressure being constant, its volume is proportional to its absolute temperature. In other words, the volume of any gas at constant pressure varies as its absolute temperature. If we combine this law, sometimes called Gay-Lussac's law and sometimes Charles's law, with Boyle's law, we reach the following law, true of all gases except in the neighbourhood of the temperature at which they tend to liquefy: *The product of the volume and pressure of any gas is proportional to its absolute temperature.*

The Absolute Scale. As was hinted in a previous section, the absolute scale of temperature assumes that heat is a definite something of which there may be more or less in a body, and which may be abstracted from a body until we ultimately reach a point when there is no more heat left. Such a body would be absolutely cold and its temperature would be the *absolute zero.* No such temperature has yet been attained, and it is very doubtful whether it can be attained by any possible device; but Sir James Dewar has been probably within seven or eight degrees of it. Now, it is plain that if our idea of heat is correct, there must be an absolute zero. The question is whether we have any indication to guide us to the point where this absolute zero is to be found. This point was determined by Lord Kelvin, to whom we owe the scale of absolute temperature, in 1848, and was reached by means of thermodynamic considerations, a term which we shall soon explain. But the reader will have already perceived that the point named—that is to say, −273° C. (on the *ordinary* scale)—is the point suggested by the law of the expansion of a gas. When we come to consider thermodynamics, we shall return to this subject. Meanwhile, we must go on to consider the expansion that heat causes in bodies other than gases.

Continued

TRANSFERS & COMMISSIONS

Transactions and Transfers. Petty Cash. Partners' Drawings. Ambiguities. Key-words. Discount. Commission

Group 7

CLERKSHIP

11

Continued from page 1469

By A. J. WINDUS

In speaking of J. Wake's acceptance, £20 10s. 6d., we have already said that had it been discounted in Glasgow, probably the net amount of £20 7s. 6d. only would have appeared in Bevan & Kirk's cash book for credit to Wake's account, and it was recommended that the 3s. discount should be journalised This affords a fitting opportunity for drawing a distinction between two terms largely used in bookkeeping —*viz.*, *transaction* and *transfer*.

What We may Learn from Physics and Sociology. Accounting, as a science, is a humble relation of the more exalted science of Sociology, which treats of the nature and development of society and civilisation, and, so far as it affects these, of commerce Now, Sociology teaches that man's activity in the material world is confined to changing the places of things. Nature, co-operating with man, accomplishes marvellous chemical and other changes ; but all that man himself can do is to marshal the various elements and forces which, acting and reacting on each other, will produce the desired results. Thus, the fire in a locomotive transforms the water in the boiler into steam, which furnishes the motive power. Nature made the steam, but man helped her by bringing the fire and the water into right relations.

Another Illustration. Take a second illustration. A golden sovereign is the outcome of transporting the precious metal from the mine to the mint, where the gold is fused with a definite proportion of base metal or alloy, and thus acquires the right degree of hardness. Omitting intermediate steps, the blended metal is presently devoured by wonderful machines of great strength and delicacy of construction. The circular coin now receives a milled edge, so that hereafter, if clipped, it will be able to tell its own story of mutilation. Furthermore, upon the obverse of the coin is impressed the profile of the reigning monarch, and a second design on the reverse. Finally, it is sent to the Bank of England, which puts it into circulation. But, in reality, man, in all these operations, has done nothing except change the places of certain things from time to time. It is man's glory that he can harness the forces of Nature, but he must obey before he can command. He cannot expect Nature to harden his gold unless he will observe the conditions on which she will perform the task. He must collect the precious metal and the base from different sources, and bring them to a place where, under the compelling influence of great heat, they will coalesce. So it is throughout the whole physical realm. If by sawing through a board we get two boards and some sawdust, it is because the shortened boards and the waste product do not now occupy the same position with respect to each other which they did before. We have changed their places.

To B Co Ld

Nature of a Transaction. From this sociological law we may draw an analogy which should enable us to see the difference between a transaction and a transfer. In course of business, the ownership of a thing may be changed, even though the thing itself is still on the premises of the original proprietors. Sometimes, indeed, an entire business "changes hands," yet the fixtures, fittings, stock-in-trade, and other property remain where they were. Nevertheless, they have changed their places, for they have passed out of the possession of their former, and into the possession of their new owners. Whenever a change of ownership is agreed to, there is a transaction. We may say then that transactions affect the external relations of persons and property, and it goes without saying that external changes ought to be faithfully reflected in the books of account. But, as in Sociology, so in Accounting ; we have not to reckon with external movements simply, but with internal changes as well. In other words, there are not only transactions, but also transfers to be considered.

Transfers. Internal changes may arise from natural causes, as depreciation and bad debts, which must be written off; from artificial causes, as clerical errors, which must be remedied; from the opening of temporary accounts whose destiny is to be swallowed up in more important accounts, and from other causes. Now, the bookkeeping operations whereby due effect is given to internal changes are known as transfers.

Example of a Transfer. Let us take an easy example of a transfer. A sold goods on credit to the B Company, Limited, for £40. Accordingly, an account was opened in the sales ledger with the B Co., Ltd. showing a debit of £40 for goods supplied. A learns some time afterwards that the company has gone into liquidation, and that there are no assets available for the trade creditors (of whom he is one) in consequence of the receiver for the debenture holders having seized the whole of the company's property. A regards the debt as hopelessly bad, and passes a transfer [see preceding page] through his journal.

As soon as the credit item of £40 is posted to the B Co.'s account, it will have the effect of nullifying the debit of £40, and the account will be balanced. It would, however, be very difficult to justify the closing of the company's account in this manner by a reference to any, or to all, of the six secondary rules of double entry given in Part IV. We readily agree that bad debt account may be debited by virtue of rule (c); but the rule directing us to credit the account of the B Co., Ltd., is lacking, and must be sought in the nature of transfers themselves.

Narrative Transfer Entry. Let us look again at our transfer entry. In common with other journal entries, it is divisible into two parts, the first part operative, the second declaratory. The latter is frequently styled the *narrative*. Its business is to state or declare the reason for making the entry, hence it is also called the "authority" for the entry. When we reach the subject of audit we shall find that auditors regard these journal narratives in the light of vouchers. Where they are not in themselves sufficient to enable the auditors to pass the journal entries as correct, they must at least furnish ample clues or references to authoritative sources of information. Judged by this standard, we should have to amend the narrative before us by the addition of the date of the letter received from the liquidator.

A Credit for every Debit. In the next place we observe that our transfer conforms to the fundamental and universal law of double entry, that for every debit there must be a corresponding credit. This is seen in the operative part of the journal entry whereby bad debt account is debited with £40 and the B Co., Ltd., are credited with a like amount.

An Internal Change. Lastly, the transfer denotes an internal change. Hitherto A has rested in the belief that his *right to receive* £40 from the B. Co., Ltd., constituted a species of property to be included among his assets under the heading of Debts Receivable or Debtors. But A now learns that the company's obligation towards himself cannot be fulfilled, and that consequently his *right* against the company is worthless. What was an asset has been transmuted into a loss, and there is nothing for it but to recognise the change. As matters stand, it is idle mockery to say that the B Co. is indebted to A in the sum of £40. It would be far better to relieve the company's account of further responsibility, and to cast the burden of the loss upon bad debt account. This is effected by means of the journal entry before us, and when the credit has been posted, the B Co.'s account in A's ledger will be closed off thus:

Dr. The B Company, Limited Cr.

	To Goods		40	0	0		By Bad Debt A/c, amt. transferred thereto		40	0	0

Function of Transfers. What, then, is the distinguishing feature of transfers? Simply this—they mediate between the various ledger accounts. Is £10 wrongly posted by being debited to Perry's account instead of to Samson's? Let us make a transfer through the journal:

Samson .. *Dr.* £10 0s. 0d.
To Perry £10 0s. 0d.

post the items to the ledger, and thus retrieve the error. From this example and the former it will be seen that one result achieved by transfers is the bringing of the figures in the ledger into harmony with ascertained facts. Other results, such as the consolidation of accounts, will be noticed in due course. We repeat that, by means of transfers, the ledger accounts are adjusted as between themselves, and in accordance with the facts from time to time revealed.

How to Transfer. In making a transfer, the all-important question is this: To which account must the item or balance be carried which now occupies a false or transient position in the ledger? Consider what is the end to be attained—namely, the carrying of the item or balance from a worse to a better place in the ledger. Remember also that the identity of the item is not affected by the process. If at first it was a debit of £10 wrongly posted to

Perry's account, it will remain a debit of £10 when carried to Samson's account, where it properly belongs. Again, the £40 debit to the B Co., Ltd., when transferred to bad debt account, is still a debit, and will never be anything else.

But to say that we may charge £40 to bad debt account, having already charged it to the B Co., Ltd., is equivalent to saying that we may now discharge the B Company's account by £40, since there must be a credit for every debit, and the only object of the transfer is to neutralise the original debit to the personal account. The same reasoning applies to the accounts of Samson and Perry.

If we burden any account with an amount originally borne by some other, we have a right to relieve the old account to the extent of the burden imposed upon the new. Similarly, when we improve or credit an account (A) at the expense of another (A A), we must take care that to A A is posted a debit equal in value to the credit posted to A.

Rule for Transfers. To transfer items or balances originally debit, *credit* the old account and *debit* the new.

To transfer items or balances originally credit, *debit* the old account and *credit* the new.

Having found room for the above in our list of rules for journalising, we may now regard that list as closed. The seven laws contained therein are the very essence of bookkeeping, hence the importance of learning to interpret and apply them. Six of these laws [see Part IV.] govern the recording of *transactions*. The remaining law relates to *transfers*, and may be consulted with advantage whenever internal changes and not actual transactions are to be registered in the books of account.

Adjustment by Transfer. Let us turn back for a moment to re-examine in the light of these remarks the supposed incident connected with Mr. Wake's acceptance, £20 10s. 6d. We will assume that Bevan & Kirk, having negotiated the acceptance with a bank in Glasgow, treated the proceeds—£20 7s. 6d.—as cash received from Wake, and merely entered that amount on the left-hand side of the cash book to credit of his account. The amount of Wake's debt was £20 10s. 6d., so that directly after his account has been credited with cash £20 7s. 6d., it will show a debit balance of 3s.

Dr. J Wake Cr.

	To Goods		20	10	6		By Cash		20	7	6

But the balance is a fictitious one, because Bevan & Kirk have obtained full satisfaction of their claim against Wake. Not only has the bank credited them with £20 7s. 6d. in account current, but Bevan & Kirk have received in addition the benefit (valued at 3s.) of prompt payment. To right matters, we must journalise the discount transaction as under:

Discount .. *Dr.* £0 3s. 0d.
To J. Wake £0 3s. 0d.
Acceptance £20 10s. 6d. discounted.

But it may be objected that Mr. Wake did not pay any money, but merely remitted a written promise to pay at a "determinable future time." Why, then, should his account be credited by cash? Now that is a perfectly valid objection. In order to meet it fully and fairly, we shall a little later on introduce a few transactions for the purpose of studying the rival methods in vogue among bookkeepers of recording the incidents peculiar to bills receivable and payable.

Given the same set of facts, two accountants will often differ in their treatment of them in the books of account, and yet they may both be right. So it is with Wake's acceptance. Although there is another way of dealing with it still to be explained, yet we should not lose sight of the fact that the bankers have paid on Wake's behalf the debt to which it relates. Therefore, it is quite logical to credit Wake's account by the amount of cash allowed by the bank.

Petty Cash Payments and Partners' Drawings. Of the series shown in Part VI., the transactions lettered (*o*) to (*u*) must now be dealt with.

Transaction (*o*), Sept. 27th. Paid from petty cash cost of advertisement for town traveller, 3s.; and for brown paper, 1s. 9d.

As both payments were made on the same date, we are at liberty, if we so desire, to enter the details on one line in the "Particulars" column of the petty cash book, placing the total of 4s. 9d. in the "Paid" column [see Part III.].

Transaction (*p*), Sept. 27th. Mr. Bevan drew £5 and Mr. Kirk £3 on private account.

There are, of course, two distinct transactions here. It would have been better if the word "cheque" had been inserted before the amounts (Mr. Bevan drew cheque, £5, Mr. Kirk cheque, £3), because as the narrative now reads, we can only *infer* that cheques were drawn. The circumstances justify the inference. We know that the practice of the firm is to lodge daily at the bank all moneys received from outside sources. We feel sure that no money has been retained out of which Messrs. Bevan and Kirk could pay themselves £8 or any other sum, because that would be contrary to rule. Neither is the required amount obtainable from petty cash, because when Mr. Bevan borrowed £7 from petty cash on September 23rd, giving an I O U in exchange, he reduced the actual cash in hand to less than £2, and the supply has not yet been replenished. We may therefore conclude that cheques were drawn for £5 and £3 respectively.

Ambiguities. Examiners in bookkeeping sometimes fall into error of the sort described above. When the meaning of a question is obscure or ambiguous it is generally because the words which would illuminate or limit the sense are lacking. Where the wording of a problem can be construed in two or three ways the candidate should base the solution on what seems to him or to her the true meaning, calling attention by a short footnote to the fact that the question is capable of different interpretations, at the same time naming them, and giving reasons for selecting one of them.

Assuming that on September 27th a cheque for £5 was drawn by Mr. Bevan on private or *drawing* account, we enter the amount under its right date on the payment side of the bank cash book. Bank cash account is credited because cash goes out from the bank, and in due course the corresponding debit will be posted to account of Mr. Bevan because he has received the cash. A similar entry is made in respect of the sum of £3 drawn by Mr. Kirk.

"Short" Entry in Bank Cash Book. On referring to the bank cash book in Part VI., it will be seen that these two amounts (£5 and £3) are entered "short," by which is meant short of the outer column, being extended into the outer column in total only. This is not an essential feature of the cash book, but the device is useful in cases where the amount of a single cheque is spread over two or more accounts. Instead of drawing two cheques the partners might have saved a penny by drawing and cashing one cheque, value £8, the proceeds to be divided among themselves in such manner that Mr. Bevan receives £5 and Mr. Kirk £3. As before, the total (£8) would appear in the outer column, while the items making up such total would go in the inner column—particulars thereof being written in the space provided.

"Short" Payment. Many readers know that the word "short" is not only used in a technical sense by bookkeepers, but has also a peculiar meaning for bank tellers. Cheques are often presented at the bank counter with a request for "short" payment. The paying teller understands by this that the payee wants his money in the smallest possible bulk. A £10 note will suit the purpose better than two £5 notes, a half sovereign is to be preferred to ten silver shillings, and so on. An uncrossed or "open" cheque for, say, £55 12s. 6d. is presented for payment. The teller puts the usual inquiry: "How will you have it?" and receives the reply: "Short." He thereupon pays out:

1 Bank of England note for	50	0	0
1 ditto.	5	0	0
1 Half-sovereign		10	0
1 Half-crown		2	6
Total	£55	12	6

"Short" Bills of Exchange. But this most convenient term has yet another technical signification. In the money market bills of exchange are spoken of as "long" or "short," and the latter include all bills which have up to ten days to run.

Acquirement of Commercial Terms. Here we may remark that the one sure method of acquiring a deep and wide knowledge of business expressions is to act on the principle of never allowing an unfamiliar term or phrase to escape until it has yielded up its secret. The special language of commerce comprises an astonishing number of technical words and phrases, and the ideal business dictionary has yet to be written. Some day, perhaps, there will arise a lexicographer of commerce, who will devote an adequate mercantile experience and reputation conjoined to literary ability and two or three years of leisure to the task of producing a standard work of reference in this department of human activity.

Consulting Authorities. This does not mean that dictionaries are "taboo," but the reverse. "In the multitude of counsellors there is safety," and whoso is wise will compare all the authorities to which he can obtain access before accepting as final the first explanation that may cross his path of a business term which is new to him. Frequently, when a strange expression occurs, a diligent study of the context will prepare the reader for the interpretation placed upon it in Pitman's "Business Terms and Phrases," and other works of reference. Very often, too, one's fellow-clerks prove kind and safe guides in matters of this sort, and their aid is not to be despised.

Key-words. Nor is it a bad plan when faced with an unfamiliar expression to try and get hold of the key-word. For instance, all certificates *certify* to something, and so a share certificate would certify that the holder was possessed of a share or shares in a certain concern. The key-word "nominal" means *in name only*, consequently, nominal account would signify an account in name only as distinguished from a *real* account or a *personal* account. Nominal capital of a company would mean the *named* but not necessarily the actual capital and so on. So much, then, for the special language of commerce of which it may be affirmed that an extensive acquaintance therewith is indispensable to all who aspire to high station in business life.

We pass to the next transaction:

Transaction (*q*), Sept. 28th. J. Bruce paid cheque, £11 4s. 8d., less discount @ 3¾ per cent. for cash, 8s. 5d.

This is a similar transaction in all respects to (*h*), which has been discussed and to which the student is asked to refer. Notice, however, that the wording is altered. In (*h*) it was "Received from Messrs. Brown & Co. . . .": here it is "J. Bruce paid . . ." In both cases Bevan and Kirk are the receivers—that is, cash comes in, and their customers are the givers. [See also Bank Cash Book, page 779.]

Another point to be observed is that in (*h*) the actual amount of the cheque was given, but in the present transaction it has to be calculated from information supplied. If the cheque was for £11 4s. 8d. less discount 8s. 5d., that is merely another way of saying that the cheque is worth £10 16s. 3d. only, and therefore we must enter as cash the reduced amount only. The 8s. 5d. discount will appear on a line therewith in the discount column, and the two amounts together will equal £11 4s. 8d. Careful study of the different modes of stating bookkeeping transactions and problems will be well repaid, and in the day of trial may enable candidates to baffle examiners.

Discount Calculations. One more point in this transaction remains to be considered—namely, the discount rate, which looks more awkward than it really is. 3¾ per cent. = 15 per cent. divided by 4; 15 per cent. = 3s. in the £, therefore, 3¾ per cent. = 9d. in the £. In like manner 6 per cent. = 5 per cent. plus ⅕ of 5 per cent.; and 5 per cent. equals 1s. in the £. Having ascertained how much 5 per cent. of the given sum is, add to the quotient ⅕ of itself, and the result will represent 6 per cent. on the original amount. The student should be on the alert to discover quick methods in calculations. The fact that 5 per cent. is 1s. in the £ will itself give him material assistance. It is easy to see that the 3¾ above referred to is 2½ per cent. plus 1¼ per cent.; in other words, 6d. plus 3d. = 9d. in the £.

Transaction (*r*) requires more thought than we might at first be inclined to bestow upon it.

Item of Rent. September 29th. One quarter's rent of business premises, £37 10s., paid by cheque.

To begin with, it is apparent that the bank must be credited, because cash is drawn therefrom. We shall deal with this aspect of the case at once and say that therefore the item of £37 10s. 0d. must be entered on the payment or credit side of the bank cash book, under date of September 29th. But having credited bank account we ought to debit some other account. Which? The seven laws of bookkeeping must be pondered if the student is unable to answer the question off-hand; but in the meantime we will go on to the next transaction, reverting to (*r*) at a fitting opportunity.

Payment of Commission. Transaction (*s*), September 30th. Received of Jones & Co. cheque for £29 8s 2d., in payment of commission £27 6s. 0d. and expenses £2 2s. 2d., to June 30th, 1905.

In all probability, the remittance has been preceded by a "commission sheet" from Jones & Co. This consists of a tabular statement of orders received from Bevan & Kirk's agency during a given period. In the majority of cases, such statements are rendered quarterly or half yearly, and, as a rule, settlements are made more promptly than in the example before us. We may suppose the present delay to have resulted from the correspondence and inquiries following upon a dispute as to the correctness of the statement, which would be drawn out in the form given on the next page.

RETURNS INWARDS JOURNAL.

1905.		September.						
Sept.	30	Aird Bros.						
		¼ doz. Blouses						
		Parisian Model at	11/1	3	6	6		
		Parcels Post.				10		
		Returned wrong pattern					3	7	4
		2.						

There is not space to reproduce the statement in all its details. Nor is this necessary, since every reader may, by the exercise of a little imagination, fill up the gaps for himself. A glance at the sectional totals leads us to believe that the invoices which are subject to 2½ per cent. commission are the most numerous, while those which are subject to 5 per cent. are few and far between.

The statement covers a period of six months. Assuming that there were, on an average, three invoices per week in the first section, six or seven invoices per quarter in the second section, and only seven invoices for the whole period in the last or five per cent. section, this would mean about 100 entries in all. Imaginary entries being duly made and the invoice amounts extended into their respective columns by the student, the money totals should now be ascertained. These will almost certainly differ from the given totals of £754 15s. 0d., £143 10s., and £96 2s. 3d. respectively, and must be brought into harmony therewith by alteration of one or more of the invoice amounts.

There are other features of the commission sheet which will be noticed at a more convenient time, but with regard to Transaction (*s*) the proper cash book entry will be found in Part VI., at page 779.

Invoice for Goods. Transaction (*t*), September 30th, Invoice No. 850, passed for goods received from Ord & Mackay, £46 15s. 3d.

A similar transaction (c) was fully dealt with in Part VII, page 977.

Returns Inwards. Transaction (u), September 30th. Goods returned by Aird Bros. (wrong pattern), £3 7s. 4d.

Now, goods *purchased* by Bevan & Kirk and returned for any cause are called "Returns Outwards." On the other hand, goods *sold* by Bevan & Kirk, and returned by their customers, are called "Returns Inwards." At least, that is the bookkeeper's name for them; but in the departments of some wholesale houses it is the fashion to refer to them, somewhat contemptuously, as "Cold pig!" It is a bad sign in any business when the returns inwards attain undue proportions. Usually, when a customer refuses to take delivery of goods ordered he has a valid reason for so doing, in that his order has not been properly executed. The ratio of returns to sales is, therefore, not an unfair test of the fidelity with which the instructions of customers have been adhered to. In the case before us the goods were returned because the pattern did not agree with the one selected by the customer. There is nothing for it but to give credit to Messrs. Aird Bros. for the price of the returned goods. This may be done by means of an entry made in the Returns Inwards Journal [see preceding page].

JONES & COMPANY,
STAR FACTORY, BRADFORD.

To MESSRS. BEVAN & KIRK,
500, Wood Street, London, E.C.

COMMISSION ACCOUNT FOR THE SIX MONTHS ENDED 30TH JUNE, 1905.

Date when Order executed.		Customer's		2½ %			3 %			5 %		
		Name.	Address									
1905.												
Jan.	4	A.	St. Paul's Churchyard, London, E.C.	42	9	4						
	5	B.	Station Road, Cardiff.							13	4	6
etc.		etc.	etc.									
				754	15	0	143	10	0	96	2	3
		Less:										
		L. Cohen & Co.	Returns	10	9	3						
		Smitherman (see last a/c)	Bad Debt							8	4	10
				744	5	9	143	10	0	87	17	5
		2½ % on	£744 5 9	....	...	...	....	...	...	18	12	1
		3 % on	£143 10 0	....	...	...	....	...	...	4	6	1
		5 % on	£87 17 5	....	...	...	....	...	...	4	7	10
									£	27	6	0
			Add Postages								5	4
			Expenses							1	16	10
									£	29	8	2

E. & O. E.

Continued

UTILISATION OF RUNNING WATER

Waterflow and Discharge. Measuring Velocity of Flowing Water. Effect of Friction upon Velocity and Discharge. Weirs

APPLIED MECHANICS
continued from page 1401

By JOSEPH G. HORNER

Harnessing Water Power. The engineer of the future will probably express astonishment at the colossal waste of water power in our days. Niagara, which "inspired us and our ancestry with reverential awe, may appeal to our descendants as only a vast electric generating station," says Professor Ayrton. Thundering over these falls, 9,000,000 h.p. runs to waste; over the Zambesi Falls some 35,000,000 h.p. is lost; while in Europe—Sweden, France, Italy, Germany, and other more or less mountainous countries—the water power utilised, compared with that available, is but as a drop in the ocean. But with the completion of works now in progress, about 700,000 h.p. will be wrested from Niagara; a project is on foot to carry the wasted power of the mighty Zambesi to the mines of the Rand, 600 miles away; and even the Japanese have schemes in hand for the utilisation of the power of the rivers Katsura and Sagami. The subject of hydraulics, then, as far as it deals with the wresting of power from water in motion, is one full of romance. Underlying practical applications, however, we have to consider many important laws and theorems, dealing with the flow of water through orifices and pipes, along watercourses, and over weirs. And here the subject bristles with mathematics of the most advanced kind. A little knowledge of algebra will, however, be sufficient to enable the student to follow the succeeding paragraphs.

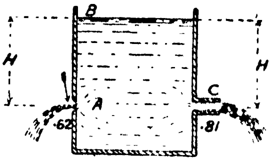
Discharge through Orifices. On page 1076 it was stated that the pressure of a liquid against a surface acts always perpendicularly to that surface. So that in **163**, if a hole were made in the side of the vessel at A, the contained liquid would issue therefrom at right angles, the parabolic curve which it forms being due to the action of gravity on the particles of the liquid after leaving the orifice. The height, BA, of the surface of water above the centre of the orifice is termed the *head*, and it is self-evident that increase of head means increase of pressure at the orifice, and consequent increase in the discharge. Now, whenever a liquid is discharged from an opening in a thin plate, as in the illustration, the issuing stream becomes contracted just outside the orifice, forming at this point what is known as the *vena contracta*, or *contracted vein*. Its position, indicated by the arrow, lies always at a distance from the opening equal to half the diameter of the orifice, and its area is ·64 times (approximately ⅝) that of the orifice. Hence the quantity ·64 is termed the *coefficient of contraction*. So much for the form of the issuing jet. Now we have to consider its velocity and quantity. Theoretically, the velocity with which the water would be discharged at A is equal to the velocity of a body falling, under the influence of gravity, from B to A—that is, through a distance equal to the head, H, of the water—and this velocity is shown by the familiar formula, $V = \sqrt{2gH}$, where $V =$ velocity in feet per second, $g =$ the acceleration due to gravity, or 32·2, and $H =$ the head. By substituting the value of g, the formula may be simplified:

$$V = \sqrt{2 \times 32{\cdot}2 \times H} = \sqrt{64{\cdot}4 \times H} = 8{\cdot}03 \times \sqrt{H}.$$

The *theoretical velocity* may thus be found with sufficient accuracy by multiplying the square root of the head of depth of water by 8. Conversely, the *theoretical head* necessary for a given velocity is got by putting H on the left-hand side of the equation:

$$\sqrt{H} = \frac{V}{8}, \quad \text{or} \quad H = \frac{V^2}{64}.$$

Friction Lessens Velocity. As the italics in the preceding lines suggest, a jet of water issuing from an orifice does not possess the velocity which theory is prepared to give it. Why is this? As soon as the particles of water in the interior of a vessel approach the orifice they converge as indicated in **163**. This convergence and the subsequent contraction, which reaches its limit in the vena contracta, give rise to considerable friction between the particles, and so neither the actual velocity nor discharge equals the theoretical total. Hence the value of V in the above equations has to be diminished by multiplying it by certain decimal quantities (coefficients of discharge), according to the shape of the orifice. In discharges through a hole in a thin plate, as in the diagram [**163**], the *coefficient of velocity* is ·97, so that the corrected equation becomes



163. FLOW OF WATER THROUGH ORIFICE

$$V = 8 \times {\cdot}97\ \sqrt{H}.$$

Velocity and Discharge. So, too, with the discharge. Theoretically, this would be the product of the theoretical velocity in feet per second and of the area of the orifice in square feet. Actually, the discharge is much less, for the velocity must be multiplied by the coefficient ·97, and the area of orifice by ·64. Therefore, if A = the area of orifice in square feet, Q the number of cubic feet of water discharged per second,

$$\begin{aligned} Q &= \cdot 64 \times A \times \cdot 97 \times \text{theor. vel.} \\ &= \cdot 64 \times A \times \cdot 97 \times \sqrt{2gH} \\ &= A \times \cdot 62 \times \sqrt{2gH}. \end{aligned}$$

·62, the product of the coefficients of contraction and velocity, is called the *coefficient of discharge*.

Substituting the value of g,

$$\begin{aligned} Q &= \cdot 62 \times A \times \sqrt{2 \times 32 \times H}, \\ &= \cdot 62 \times A \times 8 \times \sqrt{H}, \\ &= 4 \cdot 96 \times A \times \sqrt{H}. \end{aligned}$$

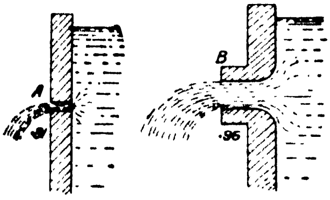
So that for all practical purposes the formula for calculating the *actual* discharge through a circular orifice in a thin plate becomes

$$Q = 5 \times A \times \sqrt{H}.$$

Partly to bridge over this considerable gulf between actual and theoretical discharge, experiments have been carried out with variously shaped orifices, and the result has been to make the actual more nearly approach the theoretical discharge. It is found, for example, that if the opening be in the form of a short tube [C, in **163**], the length of which is two and a-half to three times its diameter, the flow is greatly increased, and the coefficient of discharge is about ·81. Hence,

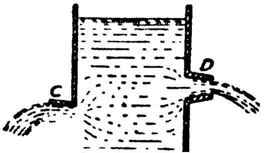
$$\begin{aligned} Q &= \cdot 81 \times A \times 8 \times \sqrt{H}, \\ &= 6 \cdot 48 \times A \times \sqrt{H}. \end{aligned}$$

If the walls of the vessel or reservoir be thick [A, **164**], so that the ratio between the length and diameter of the opening mentioned above holds good, the discharge is the same as with a short tube. But if the opening or short tube projects into the interior of the vessel the flow is less, the coefficient being about ·70. On the other hand, if the opening or tube be shaped as at B in **164**, the discharge barely falls short of the theoretical amount, the coefficient being as high as ·96 with only a moderate head.



164. DISCHARGE OF WATER THROUGH THICK TUBES

C and D [**165**] are other forms of orifices with coefficients of discharge of over ·90, and these in various guises are the forms used for the outlets of tanks. If the length of the opening be less than twice its diameter, contraction takes place as at A [**163**], and the discharge is lessened. If the tube be lengthened beyond four times its diameter, the discharge is also decreased, so that with a tube whose length is equal to six times the diameter, the coefficient of discharge is ·76; 30 times the diameter, ·65; 70 times, ·55; 100 times, ·48; in which case the openings come under the head of pipes.

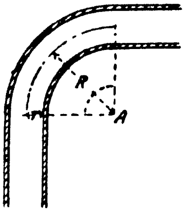


165. WATER DISCHARGE BY TAPERED ORIFICES

Flow of Water in Pipes. Thus, in long pipes the actual discharge falls very considerably below the theoretical, so that to attain a given velocity or discharge, a much greater head is required than would be expected. The total head is used up in three ways—in overcoming frictional resistance to flow within the pipe, in overcoming the resistance at the entrance of the pipe, and in maintaining the velocity of the water. In long pipes the loss of head due to friction is so great in proportion, that velocity and entry heads are neglected. The friction head may be calculated by Weisbach's formula:

$$\text{Friction hd.} = \left(\cdot 0144 + \frac{\cdot 01716}{\sqrt{\text{vel. in ft. per sec.}}} \right) \times \frac{\text{length in ft.}}{\text{diam. in ft.}} \times \frac{\text{vel.}^2 \text{ in ft. per sec.}}{64 \cdot 4}$$

The entry and velocity heads together never exceed a foot, save in short pipes.



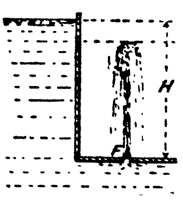
166. WATERFLOW IN WIDE BEND PIPE

Yet another loss of head in pipes is that due to bends necessitated by a change in direction. If the bend be not very sharp and be in form an arc of a circle [**166**] (as opposed to a knee, elbow, or angular bend), the additional head required is not very great; it may be calculated from the following formula:

$$H = \cdot 131 + 1 \cdot 847 \left(\frac{r}{R} \right)^{\frac{7}{2}} \times \frac{V^2}{64 \cdot 4} \times \frac{\phi}{180},$$

in which H is the additional head in feet, r [**166**] the radius of the bore of the pipe in feet, R the radius of the centre line of the bend in feet, ϕ, the central angle (at A) in degrees, V the velocity in feet per second. To maintain the velocity which a straight pipe would have given, this additional head, consumed in passing the bend, must be added to the previously calculated total head.

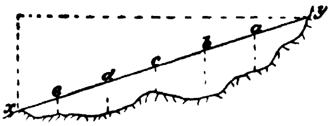
The Piezometer. The great loss of energy shown by gradually diminished pressure in a line of pipes is strikingly shown by an instrument called a *piezometer* (Gr. *piezo*, I press; *metron*, a measure) or pressure measurer. The principle on which it acts is shown in **167**. If a hole be pierced in the vessel at F, a jet of water immediately springs upwards, reaching a certain height before it falls. Theoretically, as was stated in the early part of this article, it leaves the vessel at F with the same velocity which it would have acquired in falling through the distance H,



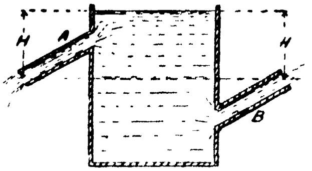
167. PIEZOMETER

and hence the jet should reach the level of the water in the vessel before falling. It fails to attain this height, partly because of the retarding influence of the atmosphere, and partly because it is hindered by the falling particles of water. It follows therefore that if an open tube were inserted at any point in a main, water would rise in the tube to a height equal to the head for the pressure at that point. The piezometer is a tube adapted to this particular purpose. In addition to its use in gauging pressure at any point, it is of great value in locating obstructions. If at any point water fails to rise in the piezometer to the height it should, it is known that the obstruction lies between the instrument and the head, but if the height registered be greater than it should, the obstruction lies in the opposite direction. By repeated experiment it is finally located.

Piezometers in Series. A series of piezometers applied to a long main, as in **168**, would reveal a steadily diminishing pressure, as shown by the successive decrease in the heights of the columns *a*, *b*, *c*, *d*, *e*. A line *x-y*, joining these levels, is termed the *hydraulic mean gradient*, or *hydraulic grade line*. A little consideration will show that such a line in a scale diagram reveals a good deal of useful information, showing, as it does, the loss due to friction or other causes from point to point. In pipes of uniform bore throughout, the gradient becomes a straight line, as in the diagram, from *x* to *y*, and as long as they lie below this line it does not matter whether, in following the contour of the ground, the pipes slope up or down. The two pipes A and B in **169** will discharge equal quantities of water with the same velocity, because they are equal in length and bore, and *have the same head*, H; yet it might be thought that because B is inclined upwards water would rise in it with less velocity than it descends A. Where frictional or other resistances occur abruptly, as when the pipes are of different diameters, the hydraulic grade line is not straight, as in **168**, for each pipe would have its own gradient.

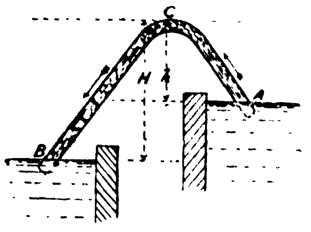


168. SERIES OF PIEZOMETERS



169. INSTANCE OF EQUAL WATER DISCHARGE

Principle of the Syphon. Before leaving the question of the flow of water through pipes, it will be of interest to refer to the principle of the syphon, a principle the application of which is of practical value in the drainage of accumulations of water to lower levels, when the pipes have to rise to a higher level than that of the surface of the water. A pipe, or, for experimental purposes, a piece of glass tubing, is bent as in **170**. The tube is filled with water, and both openings are closed until the end A is placed in the liquid; or A may be placed below the surface and suction applied at the opening B, until the contained air is withdrawn and both legs are filled with water. A stream of water then commences to flow through the syphon up the short leg AC, and down and out of the longer leg CB. Now, the pressure of the atmosphere, on the surface of the water in the right-hand tank or reservoir is the same as that on the left hand, and these equal pressures may be considered as being transmitted upwards through the legs of the tube, tending to force the water in AC down CB and vice versâ. These air pressures, then, are equal, but the pressures at the ends of the tube due to the vertical head of water are unequal. Thus, in the longer leg, CB, the water has a head, H, as compared with a head, *h*, in the shorter leg. There is, therefore, a difference of pressure, H – *h*, and consequently a flow commences through the syphon; for, as the water descends the long arm, a vacuum would be produced at C did not the water in the reservoir rise through A to fill its place (owing to the atmospheric pressure on the water surface). A continuous flow thus sets in until H = *h*; that is, the heads become equal, and the surfaces in the two vessels reach the same level, or the upper reservoir is drained. It is, of course, hardly necessary to remark that the flow would cease directly the surface of water in the higher level fell below the opening of the tube. In other words, the syphon ceases to work when the water in the vessel falls to the level of the higher end of the syphon, whether that be the leg of the ascending or descending flow.



170. THE SYPHON

Limitations of the Syphon. It has just been stated that the water rises to C (to fill the space left by the descending stream) because of the pressure of the atmosphere. Therefore, it follows that the syphon will cease working when the point C is higher than 34 ft. above the water level, for the pressure of the atmosphere is unable to support a column of greater height. Mercury, being 13·6 times heavier than water, the limiting height of C for mercury would be 30 in.; and so with any other liquid the height of the bend must not exceed the height of the barometer column of that particular liquid. As a matter of fact, it should be less, for in practice it is found that in drainage on the syphon principle, the highest point reached by the pipes must never even attain 30 ft. above the surface of the water drained. Even with quite low elevations, provision has also to be made for the escape, at the highest point, of air, which, held by the water or entering at joints, accumulates at this point, tending to lessen or even destroy the efficiency of the syphon.

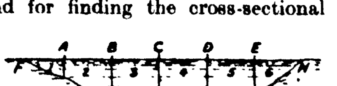
Measuring the Velocity of a Stream. It is sometimes required to measure the velocity of the water in a stream for engineering purposes, and this is a matter of greater difficulty than would be imagined. It is clear that in the case of a stream, as in orifices, pipes, etc.,

$$\text{Vol.} = \text{mean velocity} \times \text{cross-sectional area.}$$

$$\text{Mean velocity} = \frac{\text{volume}}{\text{cross-sectional area}}.$$

But the great difficulty lies in estimating the mean velocity, for the rate of flow varies in all parts of the stream. Velocity is greatest in the middle of a stream, and a little below the surface, at a distance equal to about a third of the total depth. In shallow streams, this point is found nearer to, and in very deep streams farther from, the surface. Velocity decreases as the banks are neared, while on the bed of the stream it falls to the minimum. How, then, shall the mean velocity be ascertained? As a result of long and careful experiments it has been found that the mean velocity of a stream is approximately 84 per cent. of the maximum velocity found at or near the surface in the centre part of the stream, while the bottom velocity varies between 50 and 75 per cent. of the mean. The following is, then, a ready means of roughly reckoning the average velocity of a stream. Choose a portion of the watercourse where the velocity is fairly uniform and measure off a certain distance, say 60—150 ft. On a day when it is not windy, a small float of wood is placed in the centre of the stream, and the time it takes in floating along the marked course is carefully noted; or a corked bottle is often preferred. If, for instance, it travelled 72 ft. in 18 seconds, its velocity would be 72/18 = 4 ft. per second. Then, 84 per cent. of this maximum surface velocity equals 4 × ·84 = 3·36 ft. per second = mean velocity of the stream.

A More Exact Method. For greater exactness, and for finding the cross-sectional area, a stream is divided into sections, 1, 2, 3, 4, 5, 6 [171], by means of upright poles, A, B, C, D, E, placed at equal distances apart. The depth of each portion is then taken (midway between each pair of poles), and the average depth thus found; this, multiplied by the width, gives the area of the cross-section. To obtain the average velocity of the whole, each section is dealt with separately, its mean velocity in feet per second being ascertained by a long float weighted at the bottom, so that it swims vertically, or nearly so. When each section has been thus dealt with, the average velocity for the whole of the section, multiplied by the area of the cross-section in square feet, gives the volume or discharge in cubic feet per second.



171. DIVISION OF STREAM FOR VELOCITY MEASUREMENT

There are many special instruments for measuring the velocity of flowing water at different depths. The "wheel meter" can be attached to a pole fixed in the stream so as to measure velocity at *any* depth. The flowing of the water causes the wheel to revolve, and the number of revolutions in any particular time are automatically registered by electrical apparatus. Pitot's tube is another instrument based on the fact that if a hollow glass tube open at both ends be bent at right angles and placed in a current, with one end facing upstream, water will rise in the vertical arm of the tube, and the height to which it should rise is stated by the law referred to in the early part of this article, $H = V^2/2g$. Therefore, the theoretical velocity of the stream is $V = \sqrt{2gH}$. Improved forms of Pitot's tube are so constructed that the velocity shown is the actual, and not the theoretical one.

Kutter's Cumbrous Formula. The velocity of a river or canal, instead of being estimated as we have shown by a maximum of actual observation and a minimum of mathematical reasoning, may be roughly calculated by the aid of formulæ. The most important is that of Kutter, a Swiss engineer, and though the final outcome of long and painstaking investigation, it is, as Professor Unwin says, very cumbrous. The mean velocity of a stream is:

$$\text{Mean velocity} = c \times \sqrt{\text{mean radius} \times \text{slope}},$$

the mean radius being

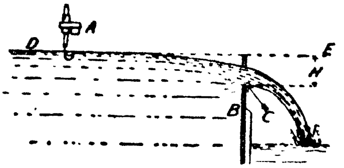
$$\frac{\text{Area of cross-section}}{\text{Length of wetted perimeter}}$$

("wetted perimeter" = length, as FGH [171], of sides and bottom against which the water presses); the slope is the fall of the stream per unit of length, say, in feet per foot; c is a coefficient which, until Kutter announced his formula, was regarded as a fixed quantity. He demonstrated, however, that the value of c is:

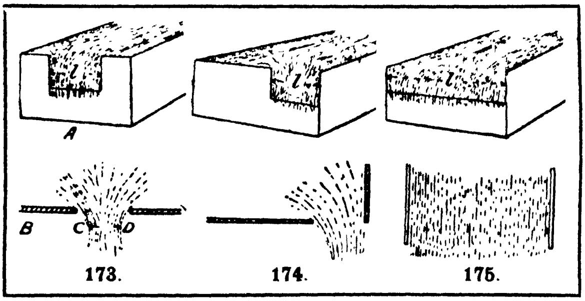
$$c = \frac{41{\cdot}6 + \dfrac{1{\cdot}811}{n} + \dfrac{{\cdot}00281}{\text{slope}}}{1 + \left(41{\cdot}6 + \dfrac{{\cdot}00281}{\text{slope}}\right) \times \dfrac{n}{\sqrt{\text{mean radius}}}}$$

In this formula, n is a coefficient of roughness of the sides and bottom of the channel, and there is considerable difficulty in finding its value, ranging as it does from ·009 for sides, and bottom lined with planed timber, to ·035 or even ·050 for a stream foul with vegetation, stones, etc. Moreover, even with the most careful calculation, irregularities in the cross-section of the stream, and in its course, may largely invalidate the values of c and V.

Weirs. The methods of calculating the flow of water just described apply only to large rivers or canals; in the case of a small stream the quantity of water available for water wheels or other purposes is best calculated by means of a weir. In 172, B is a thin plate in which is a gauge notch over which the water falls. Knowing the length of this notch and the head of water, the quantity of water flowing over the weir may be found. The length of the notch may be easily measured, but the head is not so easily determined. The head is really the distance from the point C (called the crest) to the horizontal line DE, which marks the surface level of the stream before the velocity of approach produces a sloping surface and a lowering of the level. In the diagram, H represents the theoretical head, and at this point the water would be still and the surface horizontal. In practice, however, the head is often measured only a few feet from the weir. This is done by means of an instrument called a *hook gauge* [A, 172], which consists of a round rod sliding up and down in a tube fixed to a support. At the bottom of the rod is a sharp-pointed wire, in shape like a fish-hook. The tube bears a vernier and the rod a scale, so that very minute fractions of an inch can be measured. The hook is first lowered well below the surface and then very gradually raised until its point produces a slight prominence as the surface water flows over it. The head is then estimated from the reading of the scale. Another method in which a rule is employed will be illustrated in the next article.



172. WEIR



173. 174. 175.

WATERFLOW OVER A WEIR

Calculating Flow over a Weir. Having determined the head of water, and length of weir, the discharge is found from the formula

$$Q = mlH\sqrt{2gH}.$$

Q is the discharge in cubic feet per second; l the length of weir in feet; H the head in feet; g the acceleration of gravity; m a coefficient which varies with the head, but may be taken approximately as ·41. Another formula gives the discharge as:

$$Q = 3{\cdot}33\left(l - n\frac{H}{10}\right)H^{\frac{3}{2}}.$$

Here, n is the number of "end contractions" of the weir. End contraction in a stream occurs when the weir is not the full width of the channel. Thus, in 173, with a weir shaped as at A, the stream lines will take the direction as shown in the plan at B, so that the actual length of the overflow, C – D, is less than the length of the weir l. In 173 there are, therefore, two end contractions; in 174 only one. In 175, where the weir is the width of the channel, there is no end contraction. Each contraction thus lessens the effective length of the weir to such an extent that $\frac{1}{10}$ of the head, H, must be deducted from the length, l, for each end contraction. In cases such as that in 175 it is evident that $n = 0$ and the formula would then be:

$$Q = 3{\cdot}33\,lH^{\frac{3}{2}}$$

or,

$$Q = 3{\cdot}33\,lH\sqrt{H}.$$

Difficulty of Avoiding Errors. Yet, after the most painstaking observations and the nicest mathematical calculation, the final result is often nothing more than an approximation to the actual discharge. Disregarded, apparent trifles may involve big errors. Thus, a thick crest increases the amount of friction, and so gives a less discharge than a thin plate. A rounded crest allows a greater discharge than a sharp-edged one. Convergence of the banks towards the weir has a similar effect, while the slope of the weir itself aids or hinders the discharge, according to whether it be inclined down-stream, or up-stream. Or, again, if the velocity of the water as it approaches the weir is considerable, some modification of the measured head is necessary. If, too, in weirs with no end contractions air cannot obtain free admission to the space beneath the falling water [C, 172], the resulting partial vacuum lessens the discharge. All these, and perhaps other unsuspected disturbing influences, combine to render calculated discharges, heads, etc., further from the truth than the student would expect.

Having briefly and simply touched on the questions of heads, velocities, and discharges of water in pipes, in streams, and over weirs, it now remains to deal with the practical application of this water power as seen in water wheels, turbines, hydraulic engines, centrifugal pumps, etc.

Continued

Group 4

BUILDING

11

Continued from page 1459

CEMENT MANUFACTURE

Varieties of Cement. Natural and Artificial Cements. Dry and Wet Processes of Manufacture. The Raw Materials and their Preparation

By CLAYTON BEADLE and HENRY P. STEVENS

Change of Lime to Cement. In speaking of limes, it has been shown that, owing to the presence of small quantities of clay in the original limestones, the resulting lime, known as hydraulic lime, sets to a hard mass in air, and even under water. The hardening of hydraulic limes is brought about by a chemical process quite different from the induration of mortar. In the latter case the change is due to the conversion of calcium hydroxide into calcium carbonate, but in the case of hydraulic limes other substances play a part—*viz.*, the silica and alumina of the clayey matters in admixture with this type of lime. These substances, by mutual chemical reaction, form silicates and aluminates of lime after the mortar has set.

If the temperature of the kiln be higher, the silica, in the course of lime burning, undergoes some sort of change ; it is converted into a more soluble condition than before, and is in a much better position to react with the lime to form silicates when worked up with water. Consequently, a much harder-setting material is produced than in the case of hydraulic limes. The quick-setting cements, of which Roman cement is a type, no longer possess the characteristics of lime when mixed with water ; they do not slake and fall to powder.

Portland Cement. Lastly, if we carry the burning to such a stage as to fuse, vitrify, or clinker the mass, we obtain a product resembling Portland cement, and differing markedly from all the hydraulic limes and quick-setting cements with which we have yet dealt. The older cement makers realised the radical changes produced by clinkering. When preparing such cements as Roman cement, they were careful to look over and cast aside as useless any clinkered portions ; yet it is a curious fact that the necessity of raising the temperature sufficiently high to fuse or clinker the mass is not mentioned by Aspdin in the original patent for the manufacture of Portland cement. Subsequent makers soon realised that they must aim at producing these clinkered lumps which they had formerly thrown on to the waste heap. In consequence of the high temperature in a cement kiln, the silica and alumina present in the clay react with the lime in the process of burning, to produce substances known as silicates and aluminates of calcium. These substances are able to combine with water to form hydrated silicates, which are hard rock-like substances.

The cement is dense and slow setting, and its power of setting and hardening under water is brought about by hydration of the silicates and aluminates—that is to say, the combination of these substances with water. It is now generally agreed that the setting of the cement is due to the hydration of the calcium aluminate, while the subsequent hardening is brought about by the calcium silicate.

It is an easy step to pass from a natural limestone containing clayey matter to an artificial mixture of limestone and clay which form the ingredients in the manufacture of Portland cement.

Kindred Processes. We strongly advise the student to make himself thoroughly acquainted with the course on LIMES before tackling CEMENTS.

Limestone and chalk are the raw materials in both cases, and we have not seen the necessity of repeating under CEMENTS what we have already fully described under LIMES. Much of the matter described in the BRICKMAKING course will also be found of use here. Thus, we described in that section the Hoffmann kiln, so much used in burning bricks, but also adapted for burning lime and cement.

It is also instructive to contrast the grinding machinery used in the brickmaking and cement industries. The principle of the wash-mill is the same in both, but when we come to grinding hard materials, such as limestone or cement clinker, we require a different type of apparatus altogether.

Cement has been described as a dry and dusty subject. A visit to a cement works will convince one of the dust. We shall, however, do our best to present the matter in as readable a form as possible. We should try to realise its enormous importance. Cement is coming into use more and more, not only in building the foundations of our wharves, reservoirs, waterworks, etc., but in constructive work, such as Portland cement concrete, ferro-concrete, reinforced concrete, and artificial stone. The consumption abroad, especially in the United States, is much higher than in this country, where it does not exceed one hundredweight per head.

Cement used by Smeaton and Others. Before the discovery of Portland cement there were in use a number of natural cements similar to the hydraulic limes, which are nowadays mostly replaced by the cheaper and more efficient Portland cement.

In the volcanic district in the neighbourhood of Naples there is found a sort of volcanic ash termed pozzolana. This substance contains approximately 50 parts of silica, 16 of alumina, 12 of oxide of iron, and 9 of lime. By mixing 30 parts of lime with 70 parts of pozzolana, an excellent cement is produced, resistant to the action of water. It was used in conjunction with lias lime by Smeaton for building the old Eddystone lighthouse.

It will be seen that pozzolana serves to replace the sand in mortar, but that it differs from the latter in that it is capable of reacting with the lime to form a water-resistant material.

Similar cements have been made from so-called Trass, found in the Rhine district, and Santorin earth, from an island of that name in the Greek Archipelago. Ground brick may also replace sand, and its action is similar to that of the substance just mentioned.

Natural Cements. Roman cement is a quick-setting cement, closely allied to hydraulic lime. It is a natural cement, made by calcining certain rounded lumps of stone found in the neighbourhood of the Isle of Sheppey. These stones, termed "septaria" nodules, lie embedded in the marl, just like flint in chalk, and owe their origin to similar natural processes. [See GEOLOGY.] These nodules contain, on an average, 60 to 70 parts of calcium carbonate, 18 to 20 parts of silica, and 6 to 10 parts of alumina. They are heated in conical kilns, similar to lime-kilns, and the burning is carried far enough to drive off all the carbonic acid from the mass, but not so far as to clinker it. The lumps are then finely ground. For use it is well mixed with about one-third its volume of water. It sets in from five to fifteen minutes, and under water in less than an hour.

Another similar cement, known as Medina cement, is made from a stone found in the Isle of Wight. Both these cements set rapidly under water, and where a very rapid setting cement is required, they thus possess certain advantages over Portland cement.

History of Cement. It may be truly said that Portland cement was the invention of an Englishman, and that England is the cradle of the industry. Previous to this we have the discovery of hydraulic mortars by Smeaton, who used them with such success in building the old Eddystone lighthouse; while Vicat, the Frenchman, at the beginning of the last century, was probably the first to use an artificial mixture of clay and chalk in the place of clayey limestones, as found in the natural state. The actual discovery of Portland cement we owe to Joseph Aspdin, a bricklayer in Leeds, who took out his patent on October 21st, 1824. He called his cement after the celebrated building-stone from the Island of Portland.

Aspdin's cement was originally made at Wakefield, and had already attained some notoriety before it began to be manufactured in the South of England. Here it eventually assumed enormous proportions. At the time of the Great Exhibition, in 1851, it had already attained a foothold, and begun to replace the old Roman cement. A little previous to this its manufacture was taken up by Messrs. White & Co., of Swanscombe, on the Thames estuary, and afterwards by an increasing number of firms in the same neighbourhood, until eventually the greater part of the world's production originated from Kent works situated on the lower reaches of the Thames and Medway. This is, alas! no longer the case, although more cement is still made here than in any other part of England.

Manufacture of Portland Cement. The actual manufacture falls into three distinct operations, *viz.*:

1. The preparation of the raw materials.
2. The burning of the cement clinker.
3. The crushing and grinding of the clinker to form the finished article.

The General Treatment. It goes without saying that different materials will call for different methods of preparation, but the object will always be the same—*viz.*, intimate mixing of the different constituents in a finally divided state.

In the early history of cement manufacture, as we have already explained, the raw materials were invariably soft chalk and river mud. These could be best and most safely mixed in the wet state. Both contained a considerable amount of water in the natural condition in which they were found, and were soft enough to be washed out easily by a further quantity of water, leaving stones, flints, and other impurities behind. Later on, as the demand for cement increased, it was found that equally good cement could be made from a great variety of other materials besides chalk and river mud, such as marl, different kinds of limestone, whether hard or soft, in conjunction with different sorts of clay, either gault clay or the various forms of shale and slate. Any of these raw materials can be used, provided that the chemical composition of the ingredients at hand makes it possible to produce a mixture of the proper composition, and further assuming that the raw materials do not contain dangerous constituents—such as magnesia, sulphuric acid, etc.—in such quantities as to affect the soundness and quality of the cement.

We may here mention incidentally that of late years another raw material has been largely used in the manufacture of Portland cement—in this case, not a natural stone, but a waste product—*viz.*, the slag from blast furnaces, which contains the three necessary ingredients—lime, alumina, and silica.

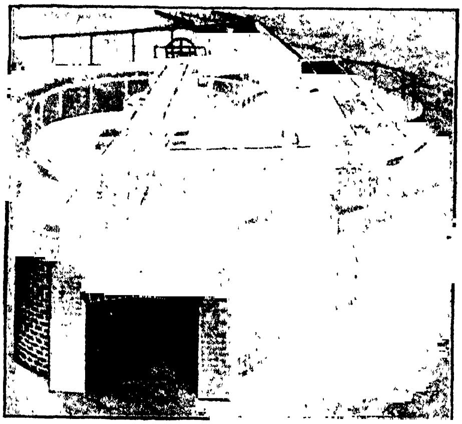
The difference in the nature of the raw materials as they are received in the factory naturally leads to different methods of treatment, and these are technically known as the different processes. Strictly speaking, there are a very great number of these, but in a general way they may all be classed under two heads—namely, the *wet* and *dry* processes. All the others can be considered as falling more or less under one or other of these processes, or a combination of the two.

The Wet Process. This method consists in washing the raw materials together into a thinner or thicker "slurry," and is, as a rule, only used in those cases where the raw materials are of such a soft nature that washing can be done by a simple apparatus called a wash mill, assisted afterwards by a grinding apparatus to reduce the slurry to a high state of subdivision. It may, however, be mentioned here that the wet process has also been used with harder materials, requiring "edge-runner" mills to disintegrate them.

In the early days of cement manufacture the wet process was exclusively employed, and a very considerable amount of water was used for washing the materials. The slurry was consequently very thin, and could be led through a system of channels, in which the coarse particles settled to the bottom, and were thus eliminated; whereas the fine, thin slurry was run into large settling "backs," or reservoirs. Here the cement material would gradually settle, and the water could be got rid of, partly by draining it off and partly by evaporation, so that after two or three months the cement raw material, or slurry, had assumed the form of thick sludge, somewhat of the consistency of soft-soap, and in this shape was taken to the kilns to be burnt.

Improvements in the Wet Process. Nowadays a more direct process has been very generally adopted, especially in England, by which the quantity of water required is greatly reduced, and a thick slurry formed, which can be pumped direct to the drying floors, so constructed as to utilise the waste heat from the kilns. The original system is known as "the Goreham process."

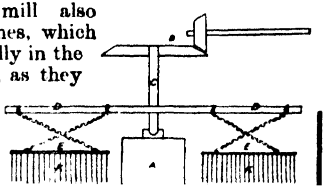
Making Slurry. In either case the apparatus usually adopted for reducing and mixing the materials is the wash mill [1]. This consists of a brick-built basin of circular or octagonal shape, about 6 ft. deep and 12 to 20 ft. across, partly sunk into the ground, with a brick-built pier or block of masonry (A) in the centre supporting the machinery. This consists of a driving gear (B) attached to a vertical shaft (C), supported at the lower end by the pier, and provided with a number of horizontal arms, termed "channel" or "angle" irons (DD). Cross harrows (EE), with renewable steel tines or metal bars (KK), are suspended by chains from the arms. The cross is made to revolve by the driving gear, and drags the harrows round in the mixture of raw material and water. By the tearing and rubbing action the raw lumps are gradually disintegrated and washed into slurry. To ensure regularity of working, means must be provided to regulate the quantity of water added, so that for a given weight of raw material tipped into the basin a corresponding quantity of water is admitted.



2. SMIDTH'S WASH MILLS

The slurry, as a rule, leaves the wash mill through a grating let into one of the sides of the mill, and the openings in this grating will, to a certain extent, ensure that the slurry possesses a uniform degree of fineness when it leaves the mill

Removing Stones from the Slurry. The wash mill also removes stones, which occur naturally in the raw material, as they will not be disintegrated by the action of the mill. These stones—such as flints from chalk, etc.—collect at the bottom of the basin, and can be periodically dug out and removed.



1. SECTION OF A WASH MILL

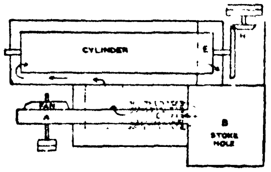
As the stones continually accumulate while the operation is in progress, the harrows must be gradually lifted up by shortening the chains by which they are suspended, so as not to work with the tines in the accumulation of stones, otherwise there would be undue friction and considerable waste of power.

The wash mill must, of course, be stopped to lift the harrows and to remove the stones.

An improved form is Smidth's mill [2], which is so arranged that the whole cross with the harrows suspended from it can be gradually lifted by turning a hand wheel. In the illustration two wash mills are shown. They are, further, built on arches entirely above ground, and at such a height that tip-waggons can go in under them. In the bottom there are openings provided with doors, which open downwards. By opening these, the stones which have accumulated in the wash mill can be emptied out with the assistance of the harrows, which should be lowered to such an extent as to scrape the stones to the openings. In this way the wash mill can be cleaned out in a few minutes instead of being put out of action for several hours. Fig. 2 illustrates this type of wash mill. The tops of the horizontal revolving arms can just be seen.

Chalk Lumps in Slurry. In modern practice, when the slurry is thick, it is necessary to grind it in order to get it fine enough. As it comes from the wash mill it may contain "nibs," or small lumps of chalk, and if these are allowed to remain without being reduced and thoroughly mixed with the clay, they will be converted into free lime in the process of burning the clinker, and the resulting cement will be unsound. With few exceptions, the only machines which have been used for grinding the slurry are millstones of the ordinary type, the slurry being pumped in through an opening in the centre of the top stone, and in many factories several consecutive passages through the stone being deemed necessary to get the slurry fine enough. Of late years, however, the tube mill, adapted for wet grinding, has come much into favour. This mill is practically the same as the tube mill for dry grinding, which will be described later on.

The Dry Process. This process can be used for practically all materials, but is most often used with those which are too hard to be treated in the wash-mill. The raw materials are ground and mixed in a dry state ; they are, with a very few exceptions, artificially dried before grinding.



3, DRYING DRUM

Drying Raw Materials. Unless the raw materials are absolutely dry as they are brought into the factory, an artificial drying is necessary, because it is practically impossible to grind a material containing moisture to a really fine powder. Even a very small quantity of water will give trouble by condensing in places where it comes into contact with cold metal, and will form a sludge with the dust, which will gradually accumulate and clog the apparatus.

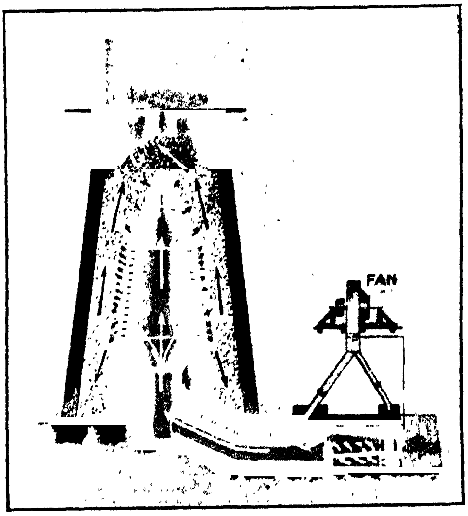
The drying has, in many cases, been done on drying flats—that is to say, floors often covered with iron plates and heated from below. [See illustration of Anderson kiln and chambers.]

In modern practice there are, however, only two methods commonly employed on a large scale.

The Drying Drum. The first of these is the drying drum, consisting of a cylinder heated from inside or outside, or on both sides, and through which the material slowly passes. The drying drum can either be placed at an angle to induce the material to pass down it, or it can be provided with ribs or projecting plates placed along a screw-line inside, so that the interior somewhat resembles an Archimedian screw with the centre cut away. The simplest form of drying drum is one used in conjunction with the rotary kiln. It forms a continuation of the kiln itself, and is heated in a simple manner by the waste heat from the kiln passing through the dryer on its way to the chimney. Besides this form of dryer there is an endless variety of designs, some consisting of only one cylinder, and some of two or more inside each other. Others are divided longitudinally into cells, to increase the drying capacity. They either utilise the waste heat in some way or other, or are provided with a special furnace fitted with an artificial draught produced by means of a blast fan.

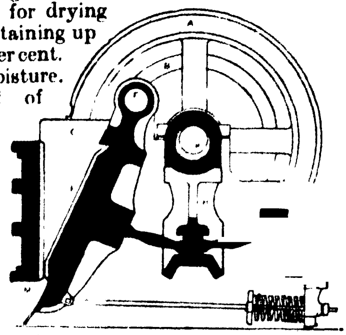
As an example of this type of dryer, we give an illustration [3]. In plant of this construction, the stokehole B is so arranged as to be under air pressure, and the air forced in by a large fan (A). From the stokehole the blast passes through the furnace C. in the direction indicated by the arrows, and forces the hot air in the direction as shown, passing first outside the drying drum and then back through the inside, finally leaving through a chimney placed above the opposite end of the drum, at E. The drum revolves, driven by the gearing shown at H.

Drying Kilns. The other form of dryer referred to above is the drying kiln. This, again, can be built in many different forms. One of the best, especially in respect to the economical results obtained, is the Smidth drying-tower. We give a section illustrating the action of this dryer [4]. In 5 is shown a typical drying-tower, one of many in use in English and foreign cement works. The drying tower is a vertical brick-built kiln of slightly conical shape. In the interior is a brick-built dome with perforated sides, connected at the bottom with a furnace with smokeless combustion—that is to say, producing heated gases free from smoke to avoid contamination of the raw material in the kiln. The furnace is operated under forced draft with air driven in by a fan. Cold air is also admitted by another channel and mixed with the hot air from the furnace as it passes on its way to the interior of the tower. The blast from the fan forces the hot air in through the dome, and distributes it evenly throughout the charge in the kiln, which fills the space between the dome and the brickwork. Around the base of the latter are a number of doors, through which the dried material falls by gravity, and the tower is kept constantly full with material put in at the top. A chimney or flue leads from a point in the upper part, and the spent air laden with moisture escapes through it.



4. SECTION OF DRYING TOWER

A drying tower of this type can be built on a large scale, and has a very considerable output. It is quite easy to build a tower to heat 200 tons of raw material every twenty-four hours, and there is practically no labour connected with it beyond stoking the furnace. A tower like this can be used for drying materials containing up to about 25 per cent. weight of moisture. The amount of fuel used is moderate, as a tower with material containing only five per cent of water will evaporate 5 lb. of water for each pound of coal burnt; whereas, when the material contains up to 25 per cent. of water, the tower will evaporate 8 lb. of water for every pound of coal burnt.

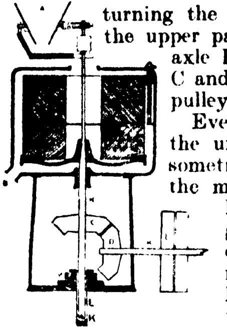

6. SECTION OF A JAW CRUSHER

Crushing. In cases where the raw materials are dried in revolving dryers, they have, as a rule, to be crushed before passing into the dryer, but where drying kilns are used, the materials are generally dried just after they come from the quarry. The large blocks are taken directly to a "jaw crusher," before going to the mills for further treatment. Fig. 6 shows a sectional diagram of the most modern form of such an appliance. The framework of the machine is in one piece, cast in steel, and very strongly constructed, as it has to stand a considerable strain. The machine is provided with fly wheels (A) and driving pulleys (B). The material is fed in at C, between the two jaws, of which one (D) is fixed, and the other (E) swings to and fro, being pivoted at F. The axle [K] carries an eccentric rod, which actuates the jaw E by means of levers. The machine is generally placed entirely underground, with a shoot leading down from the floor level to the mouth of the crusher, and a pit under the crusher with an elevator taking away the crushed material as it leaves the machine at M.

5. DRYING TOWER

[Compare plant used for grinding clay in BRICKMAKING, page 1278.]

Grinding. As already mentioned, the dry process is principally used in connection with hard materials, though such soft substances as chalk and gault clay may, with advantage, be treated in a similar way. When working with softer materials of this nature, millstones are often used for grinding, and more especially the bottom runner millstone has been found best adapted in such cases. This form has the advantage over the ordinary, or top runner millstone, in that the material during the grinding rests on the revolving stone, and consequently is moved out from the centre by centrifugal force. This relieves the stones and increases their output. A machine of this type is shown in 7. The material passes to the automatic feed by the hopper A. It passes down the middle, and then between the upper, or stationary, and lower, or revolving stone, and out at B. The lower stone is fixed to the axle H, hung up on a toe at the bottom of an iron tube L. This tube is raised or lowered by turning the nut M, threaded to fit the upper part of the tube L. The axle H is actuated by the cogs C and D, the axle K, and the pulley E.


7. SECTIONAL DIAGRAM OF MILLSTONE

Even with harder materials the under-runner millstone is sometimes used, but the harder the material and the finer it has to be ground, the greater will be the power consumed by this machine, as the stones have to be pressed very tightly together. At the same time the output of each mill will be very much reduced.

Edge-runner mills have also been used a great deal. They are heavy wheels of stone or iron running round on edge in a circular pan or trough, and crushing the material by their weight. [A description of this form of machine, such as is used for grinding clay, will be found under BRICKMAKING.] Runner mills are, however, not very well adapted for really fine grinding, and they are clumsy machines for hard brick or clinker, requiring much power, and suitable only for a few special cases.

Modern Methods. These pulverising machines are arranged to finish the grinding in one operation, but for hard materials we may economise power by dividing the work, using a separate machine for the preliminary, or coarse grinding, and another machine specially adapted for the finishing, or fine grinding.

Ball Mills. For the first operation of coarse grinding, ball mills are almost universally used. This machine consists of a drum revolving on a horizontal axis, and containing a number of heavy, hard steel balls. The periphery, or inner surface of the drum is made up of steps, and as the balls fall from step to step, they pound up the lumps of limestone or other material. Fig. 8 shows the mill in section, and 9 gives an outside view. The dust casing and fine screens, which are indicated in the sectional diagram, are not shown here.

In the ordinary ball mill the steps are formed of a number of plates projecting one over the other. These step-plates are provided with heavy steel linings, and each is fitted with a number of perforations through which the partly-crushed material falls out on to the screens. The fine part drops out into the hopper-shaped dust casing, indicated in the sectional diagram, whereas the coarse particles, which are retained on the screens, drop back through the holes in the steps into the interior of the mill again as it revolves.

The screens are generally made up of three parts—a strong plate, with slots or holes; secondly, a coarse steel-wire screen; and lastly, outside these, a wire screen of fine mesh.

The material is fed in at the centre through a hopper, and is discharged through the perforations in the step-plates.

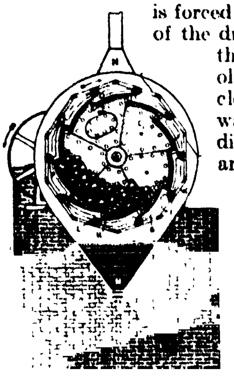
Ball mills of this description were at one time frequently used to do the coarse and fine grinding in a single operation, but since the invention of the tube mill, they are used only as preliminary coarse grinders, the finishing, or fine grinding, being effected by the tube mill, which is specially adapted for this purpose.

9. BALL MILL

Improvement on the Ball Mill. An improved form of ball mill is the Lindhart Comminutor, or Kominor [10]. This differs considerably from the ordinary ball mills. Fig. 11 shows a section of the mill, and it will be seen that the material enters A at the centre at one side of the mill, the discharge taking place through slots at P at the opposite end. The material, already partly crushed by steel balls falling over the steps C passes out at P, and then back again along the whole length of the screens E and F, which are built slightly conical in shape, and the residue, which is not fine enough to pass through the screens into the outer casing M, is lifted up at the inlet end and dropped back again through tubes N into the mill, together with the fresh material which enters at the same time.

The cylinder CD and screens fixed to the axle B revolve slowly, actuated by the pulley L and cogwheels K and H.

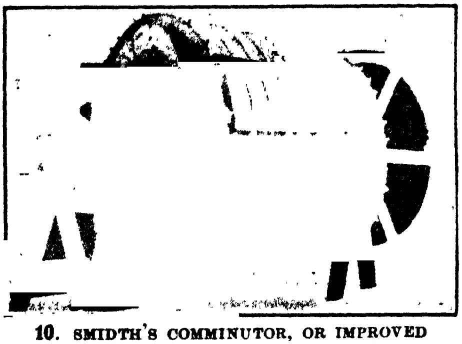
As compared with the old ball mill, this type has several points of vantage. First of all, the construction of the mill is much simpler, as the body is a plain drum, the circumference being built of a single solid plate. The steps are formed by steel castings bolted on the inside, as at D, and easily renewable. The grinding action of the mill is improved, as the material is forced to pass the entire length of the drum before it falls on to the sieves, whereas in the old ball mill larger particles invariably found their way out through the different discharge holes, and were constantly falling on the sieves, to be returned again to the mill. Another advantage in the new construction is the improved screening capacity, as the material has to pass the entire length of the screens, whereas, in the old mill the material had to go only across one window of the screens, a very short distance indeed.



8. SECTIONAL DIAGRAM OF A BALL MILL

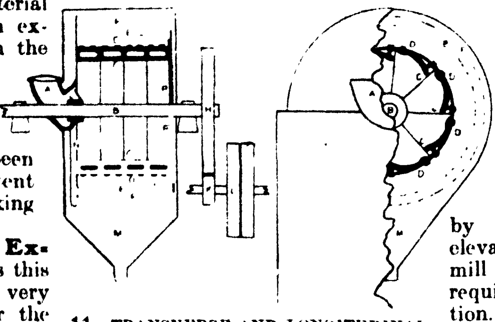
The Kominor is a very efficient machine. The largest size is made to take a charge of 3 tons of steel balls, and the capacity of the machine will be about 6 tons per hour when used for preliminary grinding of ordinary hard limestone to such a fineness that the particles will pass through a screen of, say, 20 meshes per lineal inch.

Method of Mixing. We now come to another and very important step in the manufacture—*viz.*, mixing the raw materials. In some factories, by working with very pure materials of unvarying composition, it is possible to weigh the separate raw materials in the right proportion before grinding, or even before drying, and simply to mix them together in this state. But, as a rule, they are kept separately during the drying, crushing and preliminary



10. SMIDTH'S COMMINUTOR, OR IMPROVED FORM OF BALL MILL (KOMINOR)

grinding, because it is much easier and more accurate to weigh them in the proper proportions after these operations. In those cases, especially where the raw materials vary considerably in composition, it goes without saying that large quantities of each material get mixed to a certain extent by passing through the different processes of drying, crushing and preliminary grinding, and an average composition has already been obtained to some extent before the actual mixing operation begins.

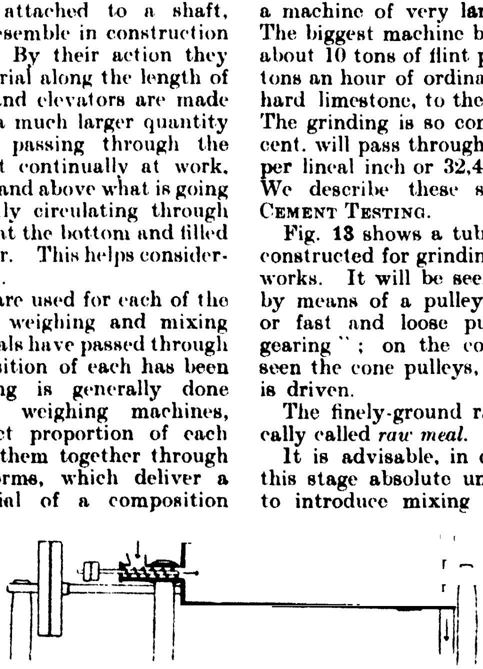

11. TRANSVERSE AND LONGITUDINAL SECTIONS OF A KOMINOR

Mixing Bins and Extracting Worms. As this careful mixing is of the very greatest importance for the uniform quality of cement, mixing bins are commonly used to make the raw materials as far as possible of a uniform average composition.

These mixing bins are generally built of brickwork or concrete, and consist of large vertical compartments fitted with "extracting worms" at the bottom, conveying the material to elevators, and thence to "distributing worms" at the top. These worms consist of spiral strips of metal bent in the form of corkscrews or gimlets. They are attached to a shaft, revolve in a tube, and resemble in construction an Archimedian screw. By their action they push the powdered material along the length of the tube The worms and elevators are made large enough to handle a much larger quantity than what is actually passing through the mills, and they are kept continually at work, so that the surplus over and above what is going to the mills is constantly circulating through the bin, being taken out at the bottom and filled in at the top of the hopper. This helps considerably to mix the materials.

Separate mixing bins are used for each of the raw materials, and the weighing and mixing are done after the materials have passed through the bin, and the composition of each has been equalised. The weighing is generally done by coupled automatic weighing machines, which weigh the correct proportion of each material, and discharge them together through a set of regulating worms, which deliver a stream of each material of a composition corresponding exactly to the ratio required.

The Tube Mill. The mixed raw materials are then passed through the fine grinding-mill. In modern practice this is almost invariably a tube mill.


12. SECTION OF A TUBE MILL

This machine [13] was invented by Mr. Davidsen. It consists of a long cylindrical drum revolving on a horizontal axis. Fig. 12 shows a section through this mill. It will be seen that the feed is at the centre of one end, and is, as a rule, actuated by means of a worm, the speed of which can be regulated at will. The cylinder is half filled with hard flint pebbles or grinding balls of other material, such as iron, porcelain or stone. The finely-ground product is discharged from the mill at the opposite end, at the periphery, through a system of slots or square holes covered with gratings, and the finished material falls into a hopper-shaped dust casing, from which it is taken away by means of a worm or elevator. The action of this mill is so simple that it requires hardly any explanation. The material "flows" through the mill by gravitation, and as it is exposed for some time to the rubbing and crushing action of innumerable flints or grinding balls, it will be ground to a very regular degree of fineness. This will also depend on the quantity passed through the machine, and consequently on the time that each particle remains in the mill. It is therefore possible to regulate the fineness of the finished product by regulating the feed.

Capacity of Tube Mill. The tube mill is a machine of very large capacity and output. The biggest machine built will take a charge of about 10 tons of flint pebbles, and will grind 10 tons an hour of ordinary raw material, such as hard limestone, to the usual degree of fineness. The grinding is so complete that 94 to 95 per cent. will pass through a sieve with 180 meshes per lineal inch or 32,400 holes per square inch. We describe these sieves more fully under CEMENT TESTING.

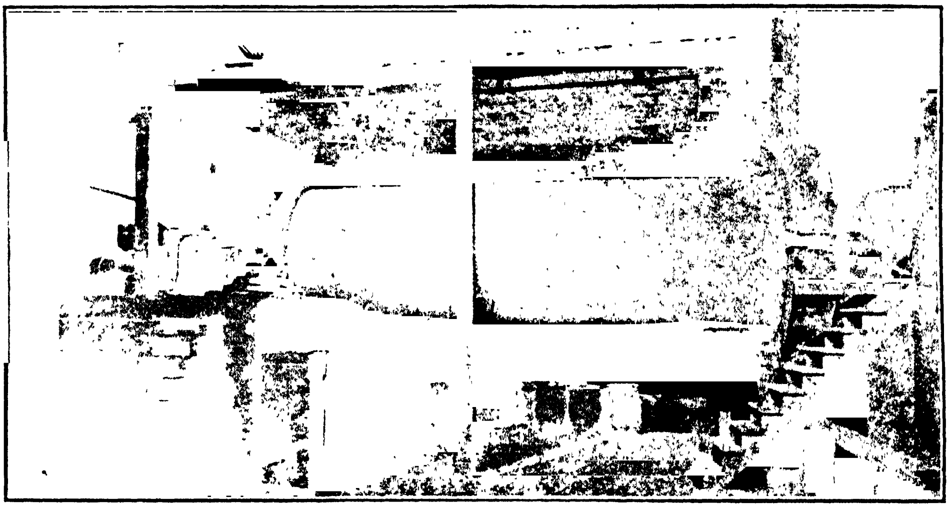
Fig. 13 shows a tube mill of the largest size constructed for grinding raw material in cement works. It will be seen that the mill is driven by means of a pulley with "friction clutch," or fast and loose pulleys, and plain "spur gearing"; on the counter shaft will also be seen the cone pulleys, by which the feed worm is driven.

The finely-ground raw materials are technically called *raw meal.*

It is advisable, in order better to secure at this stage absolute uniformity of composition, to introduce mixing bins for the raw meal, similar to those mentioned above in the preliminary grinding of the raw materials. They are provided with extracting worms at the bottom, elevators and discharge worms at the top, through which a large quantity of raw meal, in addition to the quantity necessary for the further manufacture, is constantly circulated. The introduction of big store bins at the different stages of manufacture will always be adopted by prudent manufacturers, as a local stoppage in the works will not affect the working in the subsequent stages of manufacture.

Other Processes. As has already been mentioned, besides the wet and dry processes pure and simple, others have been devised and put into operation. Various combinations of the wet and dry process are well known. The sludge dug out from the settling backs in the old-fashioned wet process is sometimes formed into bricks, with the help of ordinary brickmaking machinery, by the addition of a certain proportion of raw meal made on the dry process from the same materials. Likewise, raw meal produced by the dry process has, in some cases, been mixed with a certain proportion of slurry made in wash mills, to form a mixture which could be moulded into bricks. The resulting plastic bricks in both cases have generally to be dried in "tunnel" dryers, in which the bricks are passed through a hot oven stacked in waggons running on rails. [For details, see course dealing with BRICKMAKING, page 1278.]

Another process consists in treating the moist raw materials in their natural state *just as they are*, provided they are fairly dry, and subjecting them to the preliminary crushing and grinding in this condition, finally grinding them wet in tube mills with the addition of sufficient water to convert them into a thick slurry, which can then be treated in the same way as under the wet process.



13. DAVIDSEN TUBE MILL

It may also be mentioned here that cement is often produced from materials which are found ready mixed in their natural state. Such rocks are called "cement stone," and the resulting cement is called "natural cement." The raw materials require no other preparation than the simple quarrying of the stone.

Cement-making continued

Continued from page 1484

LIMITATIONS OF HEREDITY

Effects of Exercise. Disease and Acquired Faculties not Transmitted. Inherited Tendencies. Alcoholism. Physical and Mental Acquirements

By Dr. GERALD LEIGHTON

SUPPOSING for the moment that use-acquirements were transmitted, what would be the result? The child would grow into a normal healthy adult without exercise. It would not require to learn how to feed itself, or to walk, or to speak. All these use-acquirements which the parents had would be handed on as such to the offspring. But no such thing happens. The infant's limb never reaches the normal adult standard except from the stimulus of use, exactly as the parent's did. The power of talking and also of walking and feeding has to be acquired by each child afresh. Some of the very functions necessary to life itself must be acquired by each successive generation. Yet these characters have been acquired by every single individual of the race for hundreds of thousands of generations. Still, no child is born with them developed fully. All that the child has *is the same power of making the acquirement for itself under similar conditions.*

Changes from Childhood to Manhood. It is this power of making acquirements which has undergone such a degree of evolution. Most of the changes from infancy to manhood are due to this power. In other words, the beautiful co-ordination of all the different parts of the body in higher animals is not the result of transmitted acquirements, but is due to the facility with which acquirements can be made. Thus, if one structure varies markedly from the parental condition, all others associated with it are able to come into line, owing to the great power of making acquirements which has been evolved. The individual is enabled to adapt himself to all sorts of surroundings in virtue of this faculty. He can *become* muscularly strong in case of need, besides well equipped intellectually. Without this power the evolution of the highest animals could not have occurred, a fact which is seen most markedly in the phenomena of the mind. It is to be noted further, that the great power of making acquirements in response to use or exercise is restricted to those directions which are most commonly useful to the species. Species differ, therefore, not only in their inborn characters but also in their acquired traits. "Since this power of developing individually in response to use is an enormously important faculty which is observable mainly in the higher animals, it is, speaking comparatively, quite a recent product of evolution." [Reid.]

The Importance of Infancy. It cannot be too clearly recognised that, unless an infant makes the same acquirements as his near and more remote ancestors made, he is incapable of an independent existence. Most important, too, is it to observe that this power is not maintained at the same high level throughout life. In the human species the power of making acquirements, both mental and physical, is infinitely greatest in infancy—indeed, it is chiefly on this account that the infant grows into an adult. But as time goes on, the capacity gradually dwindles, as infancy passes into manhood and manhood into old age, and the time comes when man can make neither physical nor mental acquirements. Few of us change our opinions on any important subjects after the age of forty. Every great reform must take place by securing the attention of the young. Nothing that is acquired is transmitted; the acquirements must be made by each for himself.

The Argument from Deformities. In spite of some popular belief to the contrary, there is not a shred of evidence to show that an acquired deformity is ever transmitted. No puppy is born without a tail on account of the mutilation of the parent. All such cases as are cited are doubtless mere coincidences, otherwise they would be far more common and capable of experimental production, which they are not. No medical man ever sees a surgical mutilation reproduced in offspring. What does happen is that a child is occasionally born deformed, and the parents and others who seek to find some explanation often *assert* that it is due to some parental mutilation. But one swallow does not make a summer and the swallow may be mistaken for a martin. If transmission of mutilations were possible, millions of children would be born mutilated, and a few simple experiments would settle the matter. This does not happen, and from what we have learnt of the basis of heredity it is easy to see that it could not be so.

Maternal Impressions. If a pregnant female sees some deformity or other terrible sight, and her child when born is abnormal in any way, the case is at once quoted as one of the transmission of an acquired character. Even if it occur, it is nothing of the sort. What the mother acquires is a mental impression. What is present in the child is a physical deformity. How the former is transformed into the latter is past conception. Here, again, it is a case of being wise after the event. Millions of women see deformities and bear healthy children, and the deformed children are born in the absence of any such factor. It is a popular superstition, and, even were it true, it is not a case in point, because it is the mental impression of the mother which should reappear in the child in order that the acquirement should be transmitted. If such cases were true, they would merely prove that state of the maternal mind may in some way affect children born afterwards, not that an acquired character is transmitted.

The doctrine of telegony has also been regarded as further evidence in favour of transmission of acquirements. A mother who has borne offspring to one father is supposed so to influence offspring borne subsequently to other fathers that the later offspring exhibit some resemblance to the first father. Thus, a white woman having a child to a negro is supposed to have darker children afterwards to a white man. It need only be said here that the experiments of Professor Cossar Ewart are absolutely conclusive against the existence of telegony, and once more that, even were it true, there is no acquirement transmitted, because the mother does not thus become dark.

The Argument from Disease. Of much greater importance is the question of disease in relation to heredity. This is a very large subject, to which we can refer only briefly, and by taking certain popular examples. There is a widespread popular conviction that diseased parents produce the same disease in their children by transmission. The sins, or misfortunes, of the fathers in this respect are thought to be visited upon the heads of the children. Now, this is a crucial point in the question of transmitting acquired characters. A disease is an acquirement. If a disease be transmitted, then an acquirement is transmitted also. Once more the error is due to loose thinking and the mixing up of things essentially distinct. Take one or two well-known diseases, supposed by many to be hereditary. Gout is constantly quoted as a case in point. Tuberculosis, or consumption, is said to be transmitted.

These two will serve as examples. Keep clearly in mind that characters are of two sorts—*germinal*, or inborn; and *somatic*, or acquired. Disease is somatic, acquired. The tendency to a disease, however, is often germinal, or inborn. That is much the same thing, someone objects. Not at all. A tendency may be counteracted by suitable surroundings, so much so that it may never be acted upon. A disease is an actuality, an accomplished change in body tissues.

Inherited "Tendencies." The mistake is in confusing disease with the tendency to disease, or diathesis. Some persons are so constituted innately that, if exposed to the infection of consumption or to the causes of gout, they will develop these conditions. They have an inherited tendency, and this is inherited because it is a germinal character, and nothing that they have acquired.

There is absolutely no evidence that high living on the part of the parent influences the tendency of the child to gout, nor that generations of high living tend to evolve a generation of gouty individuals. What happens is that if an individual comes of a family in which the gouty tendency is innate, then under certain conditions he will get gout. He will not transmit that gout to his children, but they will have the gouty tendency whether he gets the disease or not. Similarly with tuberculosis, which is never inborn. The tendency is inborn and transmitted, and the child acquires the disease as the parent did. But if the child with the consumptive inborn diathesis be placed in a good climate and not exposed to infection, it will grow up healthy be its parents ever so consumptive.

It need hardly be said, except that it is little realised, that a child may acquire disease while still unborn. But this has nothing to do with heredity. In such a case the child acquires the disease from the mother by infection, just as the mother did from some other source. It is not inherited, because it is not germinal or inborn. A child would not be said to have inherited a bullet which had passed through the mother and lodged in a developing child before birth; yet disease is constantly spoken of as inherited in this loose way. The incident of birth has no bearing on the question of heredity. Many things happen before birth which are not matters of heredity but of acquirement by the child. An unborn child may take smallpox from its mother; it does not inherit smallpox in any real sense of the word, it takes it just as it might take it after birth.

Diseases Spontaneously Inherited. The only diseased conditions which are inherited are those which are inborn, or germinal, just as in the case of any other traits. Thus, if a child be born having six fingers instead of five, that morbid condition may appear in the succeeding generations as a hereditary character; because its origin is germinal, it is a spontaneous variation. So in that curious disease called "hæmophilia," in which the sufferers are termed "bleeders," because, if for any reason they begin to bleed, it is impossible to stop the flow. That disease is truly hereditary, and in a very peculiar manner. It occurs chiefly in males, females being rarely affected. But the transmission is not as a rule, from father to son, but almost always through apparently healthy members of the female line to the male descendants. It is a striking example of a trait which can be explained only by the continuity of the germ-cells from generation to generation. A somewhat similar mode of transmission is seen in some other diseased conditions. Apart from heredity there is no known cause of a disease such as hæmophilia, and in this case heredity is not the original cause but merely the means by which the disease reappears.

The Effect of Disease on the Race. If disease, then, be not transmitted as such to offspring, what part does it play in the process of racial or national evolution? We have answered this question on a previous page in this course [see page 826], to which reference may again be made here. Disease, if sufficiently widespread to be a cause of selection, operates by causing the survival of the fittest—those who have an inborn immunity to that special condition or those who have an inborn capacity to acquire immunity. What the nature of this immunity is we shall see when we study bacteriology. But it may be stated at once that were such an acquirement as disease transmitted from parents to offspring, then it follows that each succeeding generation would be more and more diseased until they all ultimately perished from it. Of course, no such thing happens, the race gradually becomes immune or resistant from natural selection.

The Case of Alcoholism. No case is more often quoted, or rather misquoted, than that of alcohol and drunkenness. Time after time we see it stated that the terrible effects of drink are to be seen in the offspring of drunken parents, and that here is a case of transmission of an acquired character. Once more the belief is due to ignorance of the facts, and to the same error of confusing germinal with somatic characters as before noted. There are individuals with an inborn germinal tendency to become drunkards, a true hereditary tendency, for which they are not to blame, but for which they deserve our unstinted pity. Whether they succumb to this tendency or not, it is handed on to their children, generation after generation, until the individuals have all been eliminated by selection. On the other hand, there are others who acquire the drunken habit for various reasons of environment. They do not transmit their acquirement to their children, but the children may, of course, acquire it in their turn for themselves, just as their parents did. So that the offspring of drunkards will probably be drunken or sober, according to the origin of the parental weakness. As a matter of fact, drunkards are just as often the children of most sober parents as they are of drunken parents, because they have acquired the habit.

So, also, many sober individuals had drunken parents, but because theirs was an acquired habit the children escape, or, at least, have every opportunity of so doing. True hereditary alcoholism is not very common. Drunkenness is common because a great many have the capacity for acquiring the habit; not all, however. Many sober persons are so because they are comparatively immune, or very resistant. Drunkenness is a great selector, and in time weeds out the least resistant. So the nations which have had the longest experience of alcohol are found to be the least drunken—the Jews, for example. If acquired habits, such as the alcoholic habit, were transmitted to offspring, the race exposed to alcohol would get more drunken with each succeeding generation, which does not happen any more than it does in the case of diseases. We shall return to this point in connection with physical deterioration.

The Argument from Mental Traits. Just as physical acquirements, such as big muscles and bodily disease, are not transmitted to offspring, so even more markedly are mental acquirements non-hereditary. We are all too familiar with the fact that we, each of us, have to acquire, by long and painful steps, the mental traits of those who went before us, unless the trait be an inborn one. Put in the simplest way, all that we *learn* individually has to be learnt over again by our children, who do not inherit our mental acquirements. They are use-acquirements, and arise through exercise and stimulus, and, like other use-acquirements, are not transmissible. But the full import of the mental and also the moral aspect of the question can be grasped only when we have considered the last part of our task—namely, the evolution of mind, and it is to this problem that we must turn our attention.

Evolution of Mind. A number of interesting views have been held as to the mode of the evolution of the human mind. It is entirely beyond our province here to review these—some of them will be dealt with when we study psychology—we can only indicate the lines which appear to us to have been followed. The works of Herbert Spencer, Romanes, Lewes, and others must be consulted in order to learn what has been the course of thought on the subject.

The problem of the evolution of mind and reason has long been discussed from the starting point of instinct, and the attempt has often been made to derive the former from the latter. Spencer regarded instinct as compound reflex action [see PHYSIOLOGY], and as the forerunner of intelligence. Lewes, on the other hand, regarded instinct as lapsed intelligence, and, therefore, as the successor of intelligence. The one thought that no instinct need ever have been intelligent; the other that all instincts must at one time have been so. Romanes agrees partly with both and totally with neither; he thinks that some cases are accounted for on Spencer's view, some on that of Lewes's. All three theories assume that acquired mental characters are capable of transmission and accumulation in subsequent generations.

Instinct and Intelligence. We are quite unable to accept this assumption, which appears to us contrary to all the evidence obtainable. We do not believe that intelligent action arises out of instinctive action which has become too complex to be purely instinctive, because some instinctive acts, such as the web-spinning of spiders, are very simple; we hold that the two are perfectly distinct and that instinct does not merge into reason at any point.

There is no more ground for thinking that instinct arises from intelligence than for thinking that intelligence came from instinct. Mental acquirements are not transmissible. "Having arisen in the parent through the stimulus of use, they do not arise in the offspring through the stimulus of nutrition. . . . It is impossible to understand why the mere co-ordination in a ganglion of purely physical stimuli should result in consciousness. It is equally difficult to understand why the mere compounding of reflexes should necessarily result in desire, memory, reason. . . . Were mental characters transmissible, the human race would long ago have lost—indeed, would never have achieved, that mental 'plasticity' which is its special endowment. The stereo typed knowledge, beliefs, prejudices, sentiments, of the adult would appear in a stereotyped form in the child. . . . A race that had long spoken a given language would speak it instinctively, though the children were reared by people who spoke another tongue. There would be no deaf mutes, for, however deaf, the mutes would still talk instinctively. A race that lived under conditions—*e.g.*, the presence of alcohol or opium—that adversely affected the mind would deteriorate until it perished." [Reid.]

Acquirements and Instincts. The outstanding phenomenon in the higher evolution of man is the extent to which his mental acquirements have replaced his inborn instincts. And here is the essential difference between instinct and reason—instinct is germinal, or inborn; reason is somatic, and acquired. Man has evolved an immense power of making acquirements, and in no part of his nature is this so striking as in his mental characters. This power is germinal, and therefore transmissible, and it is in virtue of it that he has become the reasoning creature he is.

" With the exception of the desire for rest and sleep, when wearied, nearly all his remaining instincts are mere incitements to make acquirements. Men and women endeavour by acquirements to increase their powers of fascination. The mother learns to tend her offspring. . . . Both sexual and parental love, or, to speak more correctly, the capacity to feel them, are acquirements. It is very doubtful whether the human male has any ' natural affection ' for his children. He acquires his love for them as he may acquire a love of country, or of a particular religious system, through the incitements of his imitative instincts. It is notorious that the custom or fashion prevailing in any race or class largely determines whether the men and the women composing it shall be good or bad parents; whether they shall tend or neglect their children. Many races, ancient and modern, savage and civilised, have practised infanticide without pain or compunction. . . . Sexual love, as idealised among modern Western nations, is plainly an acquirement. It is quite a recent character. . . . Ancient communities showed no trace of it, and many modern communities show none. . . . An appreciation of sexual beauty is supposed to be instinctive in human beings, but in a great measure it, also, is plainly a matter of acquirement. . . . Female heads devoid of hair are much admired in parts of Africa, as are shaven male heads in some other lands. . . . Modesty is supposed to be an instinct. . . . But the baby has no trace of it, and apparently would not develop an iota but for his imitative faculty. Various savages have no more modesty than a lower animal. Only those races that wear clothes are modest—at any rate, in the Christian or Mahometan sense. . . . A manifest tradition, a mere acquirement, modesty has become stronger than any instinct. . . . The Turkish woman is modest about her face; the English woman delights in displaying it. . . .

Morality an Acquirement. " Morality is said to be an instinct. But there is no evidence that any human individual or race ever possessed any morality, except such as was acquired through the imitative faculty, or, in rarer cases, through reasoned thought. The extraordinary diversity of moral systems . . . is conclusive evidence that morality is no other than an acquirement. . . .

" Fear and hate are said to be instincts. As a fact, in man, they are acquired emotions. The adult fears or hates nothing except that which he has learned to fear or hate. . . . The new-born infant neither fears nor hates anything." [Archdall Reid.]

These copious quotations from Dr. Reid's recent work show that most of the so-called instincts in man are really mental acquirements, and it is in the immense power possessed by man of making these acquirements that he differs from the merely instinctive animals.

Continued

continued from page 1364

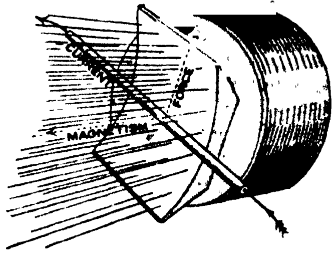
THE ELECTRIC MOTOR

Electric Motive Power. Cost of Electric Power. Continuous Current Motors. The Propelling Drag. Voltage and Speed. Starting Devices

By Professor SILVANUS P. THOMPSON

Electric Power. An electric motor is a species of engine which runs by electricity, and will give out mechanical power. In other words, it is a contrivance for converting the energy of the electric currents with which it is supplied into the energy of mechanical movement, and so doing useful work.

The way in which the electric motor does this is founded upon the mechanical action that exists between a copper conductor that is carrying the current and the magnetism of a neighbouring current. A magnet pole neither attracts nor repels the wire that is carrying an electric current, for the action is a *lateral* one; the force which the magnet exercises upon the conductor is a sideways force tending to urge the conductor laterally past the pole.



87. MAGNETIC DRAG ON CONDUCTOR CARRYING CURRENT

The principle of the electric motor was discovered in 1822 by Faraday when he succeeded in causing a copper wire carrying a current to rotate around the pole of a bar magnet which stood in a pool of mercury into which the lower end of the wire dipped.

Motors for Continuous Currents. Motors to be supplied with continuous currents from batteries or from a dynamo differ somewhat in design from those intended to work with alternating currents. Some of the latter kind, called ***induction motors***, are described hereafter in our discussion of THREE PHASE. The present chapter is devoted almost exclusively to motors for continuous currents. All such motors consist of the following essential parts: An *armature*, on which are wound the conductors which carry the current, and which revolves; the ***field magnet***, which produces the magnetism to act on the conductors and drive them past the poles; the ***commutator*** and ***brushes***, which provide sliding contacts between the revolving conductors and the wires that bring the currents from the supply mains. It will be seen that these essential parts are the same as those of a dynamo [page 1104]; in fact, every dynamo will act as a motor if supplied with current at the proper voltage, and every motor will act as a dynamo if mechanically driven at the proper speed.

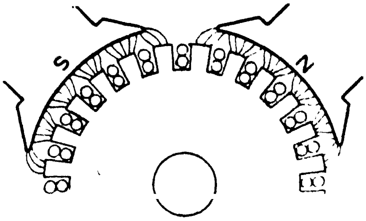
Power. Power is scientifically defined as ***the rate of expending energy*** in doing work. It must, therefore, not be confused with *force* (which is a mere push or pull), or with *energy* (which is the product of power and time). A force can be expressed in terms of the equivalent weight in *pounds*. Energy can be expressed in terms of *foot-pounds—i.e.*, as equivalent to lifting a pound so many feet high against gravity. But power will be expressed in terms of the number of *foot-pounds per minute* that are being expended in useful work. We have seen [page 290] that by James Watt's definition, universally accepted by engineers, 1 h.p. is equivalent to 33,000 foot-pounds per minute. This is the same *rate* as 550 foot-pounds per second, or as 1,980,000 foot-pounds per hour.

But power may be equally well expressed in terms of electrical units, for, as pointed out on page 290, 1 h.p. is the equivalent of 746 watts. This figure must be borne in mind in all calculations about electric motors.

Power of Electric Motors. The user of an electric motor generally has some idea, more or less vague, of the amount of power that he requires his motor to give. The following are a few statistics about the power needed for driving different kinds of machinery:

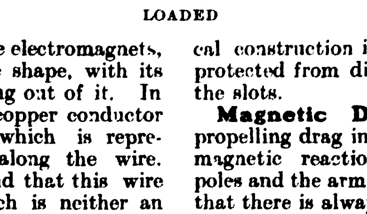
	Horse-power.	Watts.
Wood-working Machines :		
Fret saw (cutting 1 in. plank)	0·3 to 0·5	224 to 373
Band saw (20 in., sawing 4 in. plank) ..	3 ,, 4	2,238 ,, 2,984
Circular saw (36 in., sawing 10 in. teak)..	14 ,, 16	77,584 ,, 79,076
Light lathe	0·6 ,, 1·0	447 ,, 746
Engineering Tools and Machines :		
Capstan lathe (6 in. for brasswork)	1 to 2	746 to 1,492
36 in. lathe (high speed, cutting mild steel)..	20 ,, 30	14,920 ,, 22,380
Milling machine ..	1½ ,, 4	1,119 ,, 2,984
Shop crane	1½ ,, 4	1,119 ,, 2,984
Miscellaneous :		
Lift for hotel	1½ to 4	1,119 to 2,984
Small printing machine	½ .. 1½	373 ,, 1,119
Rotary press (2,000 sheets per hour) ..	12 ,, 15	8,952 ,, 11,190
Rotary press (20,000 news-sheets per hour	30 ,, 40	22,380 ,, 29,840
Small fan motor ..	0·05 ,, 0·1	37 ,, 75
Sewing machine ..	0·1 ,, 0·15	75 ,, 112
Organ blower	0·3 ,, 2	225 ,, 1,492

Now, remembering [page 292] that the number of watts of power used by the motor is the product of the number of amperes it takes from the mains into the number of volts at which the current is supplied, we can find (approximately) how many amperes any motor will take by dividing the number of watts it consumes when at work by the number of volts of supply. Thus, if we wanted to know how many amperes would be taken by a motor for blowing a large organ in a town where the voltage of supply was 220 volts, we observe from the table that we shall want a 2 h.p. blower, consuming 2 × 746 = 1,492 watts. Then dividing 1,492 by 220, we find as the necessary current at least 6·78 amperes. A fan motor of $\frac{1}{10}$ h.p.—that is, 74·6 watts—if the supply is at 100 volts, will take about 74·6 ÷ 100 = 0·746 amperes, or a little more than an ordinary incandescent lamp. As a matter of fact, in each case the current will be a little more than that calculated, because of the slight loss by friction in the motor itself.



88. MAGNETIC FLUX IN MOTOR AT NO LOAD

Cost of Motor Power. This obviously depends on the price of electric energy per "unit." The "unit" by which energy is charged is 1,000 watt-hours; and the charge per "unit" varies in England from 1½d. to 4d. to retail customers. Suppose a small factory to require a 20 h.p. motor, which is sometimes running full load, sometimes at a smaller load, but which averages 15 h.p. during a working week of 64 hours. Assume also (allowing eight days complete stoppage for holidays, besides Sundays) that there will be 51 working weeks in the year, the cost of power will be calculated thus: Multiplying 15 by 746, we get 11,190 watts, or 11·19 kilowatts, as the average power. In one working week the number of "units" consumed will be 11·19 × 64 = 716·16; and in one year will be 51 × 716·16 = 36,524 units. At 1½d. per unit, this amounts to £228 10s. 6d., whereas had a small steam-engine been used the cost would have been over £300.



89. MAGNETIC FLUX IN MOTOR WHEN LOADED

The Propelling Drag. The drag which the magnetic field exerts upon the conductor which carries the current is illustrated diagrammatically in **87**. This represents the pole of one of the electromagnets, a north pole of nearly square shape, with its invisible magnetic lines radiating out of it. In front of this pole there lies a copper conductor carrying an electric current, which is represented as flowing from us along the wire. Then it is experimentally found that this wire is acted on by a force which is neither an attraction toward the pole nor a repulsion from it, but a mechanical drag tending to shift the wire sideways to itself, and upwards past the pole. If the pole were a south pole instead of a north pole, the drag on the current coming toward us would be downward instead of upward. If the pole were still a north pole, but the current had been reversed in direction so as to flow towards us instead of from us, then the drag would be downward. Reversing the sense of either of the two elements (the magnetic field or the current) reverses the direction of the mechanical force. But if both were reversed at once the mechanical force would still be upward.

Calculation of Force on a Conductor. The formula for calculating the amount of force acting in such a case is this. Let the symbol **B** stand for the flux-density—that is, the number of lines per square inch at the pole surface; C_1 for the current (amperes) carried by one wire; l, the length of wire crossing the flux, being the same as the length across the pole face; then the force f, in pounds, with which the wire is urged across the pole, is given by the rule:

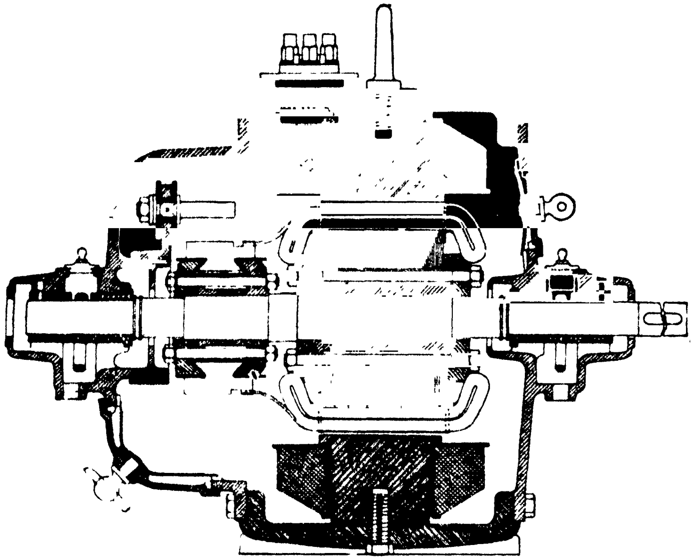
$$f = B \times C_1 \times l \div 11{,}303{,}000.$$

For example, if $B = 45{,}000$ lines per square inch, $C_1 = 10$ amperes, and $l = 5$ in., then $f = 45{,}000 \times 10 \times 5 \div 11{,}303{,}000 = 0{\cdot}199$ lb.

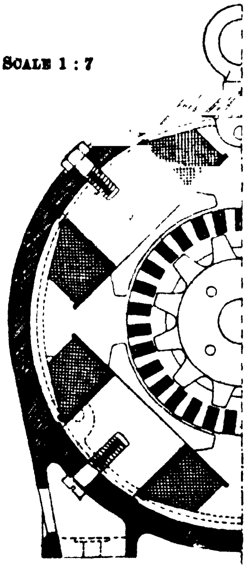
In some old patterns of motors the armatures had smooth iron cores, with the copper windings lying on the outside of them, bound on by binding wires. In such cases the copper wires were dragged by the action of the magnetic field, and this drove the motor. For instance, if in some such motor the drag on each wire had been, as calculated above, about one-fifth of a pound, and if there had been 400 such wires passing under the various poles, the total peripheral drag tending to turn the armature would have been equal to 80 lb. But in modern motors, the armature cores are always built up of toothed core-discs, and the copper wires (properly insulated) are wound in the slots between the teeth. In that case, the propelling drag does not come upon the copper wires, but comes upon the iron teeth, and drags them round. The amount of the force is just the same as if it came on the wires, but the mechanical construction is far better, as the wires are protected from displacement by being sunk in the slots.

Magnetic Drag. We may regard the propelling drag in the motor as the result of the magnetic reactions between the field-magnet poles and the armature. We know [see page 560] that there is always a tension along the invisible magnetic lines, which act as though they tended to shorten themselves. Now, suppose we represent, as in **88**, two of the poles of a 4-pole motor and the piece of the armature opposite them. If there is no current in the armature, the magnetic lines from the poles will cross to the iron teeth of the armature nearly straight across the clearance, and each pole will pull directly at the teeth opposite, and this pull will not tend to drive the armature either way. But if, as in **89**, the armature wires are carrying currents (the dots and crosses represent currents coming towards or from us, as explained on page 1321), then the magnetic lines will be distorted, as shown, and will cross the gaps obliquely to the teeth; and in that case there will obviously be forces tending to drive the armature and make it turn.

Torque, or Turning Moment. The mechanical tendency to turn anything around an axis of rotation is called by engineers *the torque*. It is also called the *turning moment*, or *angular force*, or *couple*. The torque, or turning moment [see MECHANICS] due to any force is equal to the product of the force and its leverage. Thus, if a force of 10 lb. acts with a leverage of 2 ft., there is a torque, or turning moment, of 20 *pound-feet*. The name of one *pound-foot* is given to that amount of torque which is exerted by a force of 1 lb. acting at a radius of 1 ft.



90. MOTOR OF 5-HORSE POWER (LONGITUDINAL SECTION)



91. (TRANSVERSE SECTION)

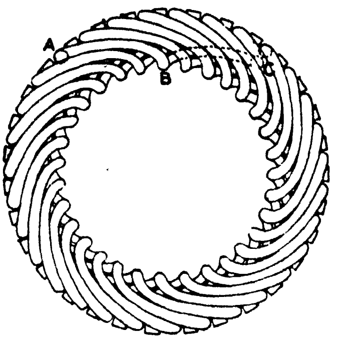
Those not familiar with precise scientific terms must not confuse between 1 pound-foot of torque and 1 foot-pound of work; for the pound-foot, which is a turning effort, is the product of a force exerted tangentially, into a length at right angles to it—that is, radially; whereas, the foot-pound, which is the work done in a movement, is the product of a force into a length in the same direction as itself.

Speed, Torque, and Power. Power, being a product of effort and speed, expressible in foot-pounds per minute, may be stated in two ways; either (1) as product of torque and angular speed, or (2) as product of peripheral force and surface speed. By angular speed is meant the number of *radians* (one *radian* being the unit angle in circular measure, see GEOMETRY) per minute, and is calculated by multiplying the number of revolutions per minute by 2π ($=6·28$). Thus, a body revolving at 600 revolutions per minute has an angular speed of 6·28 × 600 = 3,768 radians per second. We may take as an example of both ways of calculating power the case of a motor armature 9 in. in diameter, having a total peripheral force of 134 lb., and revolving at 600 revolutions per minute. How much power is it giving out? The radius is 4½ in., or 0·375 ft.; then, multiplying the peripheral force of 134 lb. by the leverage of 0·375 ft., we see that the torque is just over 50·25 pound-feet; and 50·25 pound-feet multiplied by 3,768 radians per minute = 189,342 foot-pounds per minute, which, divided by 33,000 to bring it to horse-power, gives 5·75 h.p. Or, calculating by the second method, the surface-speed will be equal to revolutions per minute (= 600) multiplied by circumference (= 0·75 × 3·14 = 2·366 ft.), and is therefore 600 × 2·366 = 14,166 ft. per minute; and, multiplying this by the peripheral force of 134 lb., gives as the power 1,416 × 134 = 189,342 foot-pounds per minute, or 5·75 h.p., as before.

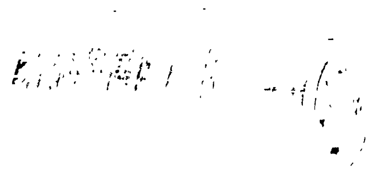
A Modern Motor. Let us study a modern motor, such as is depicted in **90** and **91**, capable of giving out, when tested by a brake, 5 h.p., when running at 600 revolutions per minute, and so wound as to be suitable to work on mains supplied at 220 volts.

Now, we know that if it is to give out actually 5 h.p. it must actually receive more than the equivalent electrically, because of the inevitable losses due to friction, armature heating, and the like. If we estimate these losses at, say, 15 per cent., the motor must receive from the mains the equivalent of 5·75 h.p.—that is, 5·75 × 746 = 4289·5 watts. Now, dividing the watts by the volts gives the amperes; or 4289·5 ÷ 220 = 19·5 amperes will be the current it will take from the mains.

The construction of this motor is as follows. There are four poles, each having a flux of about 1,180,000 magnetic lines, and as the surface of each pole is about 26 sq. in., the flux density at the pole-face is about 45,000 lines per sq. in. The armature core is built of toothed core-discs, like **57** [page 1106], 9 in. in diameter to a length of about 5 in. They have 31 slots, 1 in. deep. The armature coils are former-wound, like **55** [page 1105], 15 wires being taped together in each coil, and the coils assembled two-deep in the slots, as in **92**, so that each slot carries 30 wires. The coils, bent like the one marked ABC, are fitted in symmetrically, and fixed by wedges and binding wire. This makes the total number of wires around the armature 930, of which not more than about 670 are at any one time actually passing under the poles. The grouping of the coils constitutes, as explained on page 1323, a series-parallel winding with two circuits through the armature, like **68** [page 1323]. At full load, each wire, therefore, carried 19·5 ÷ 2 = 9·75, or nearly 10 amperes. The drag on the armature may be calculated as though it came on the wires, and, according to the rule laid down above, will be 45,000 × 10 × 5 ÷ 11,303,000 = 0·199 lb. per wire, or about 6 lb. per tooth under the poles, or in total about 0·199 × 670 = 134 lb. The commutator has 93 segments, and is 8 in. in diameter. The field-magnet coils consist of 1,200 turns each of a fine wire carrying about one ampere.

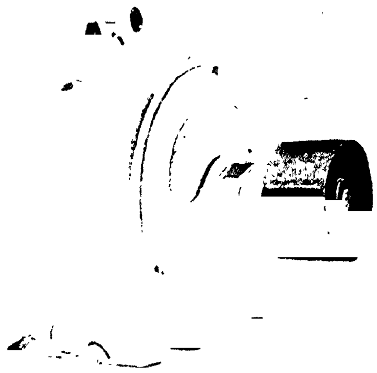


92. ARMATURE WINDING, END VIEW



93. ARMATURE OF MOTOR

Fig. **93** shows a view of an armature of such a motor when completed, and **94** gives an external view of the whole machine. Small motors under 5 h.p. are often made bipolar, with field magnets like **45** or **46** [page 1104].



94. COMPLETE MOTOR OF 5-HORSE POWER

Protected and Enclosed Motors. Sometimes motors are left entirely *open*, and then they resemble the 4-pole dynamos depicted in **44** [page 1104]. More often now they are built with end-shields which support the bearings, and thus protect the armature ends, the commutator, and the brushes, such forms being described as *protected* motors. Others are *enclosed* by having the spaces in the end-shields covered with perforated metal; while others, again, are *totally enclosed*, to enable them to be used in factories where an explosive gas or combustible dust is present in the air. As enclosing a motor prevents the cooling of the internal parts by access of air, they have to be given a lower rating; thus, a motor which, if open or only protected, was rated at 5 h.p., could only be rated at 2½ or 3 h.p. if totally enclosed.

Voltage and Speed of a Motor. There is a fixed relation between the voltage applied to a motor and the speed at which it runs, provided the magnetism of its poles remains constant. For if we regard the revolving armature, as on page 1591, as acting like that of a dynamo, we may calculate what voltage its conductors will create by cutting the magnetic lines. Every motor does this, and necessarily creates a back-voltage which can, however, never be greater than that which is applied to its armature. In fact, every motor tends to run up to such a speed that it generates a back-voltage equal to that part of the actual voltage that is applied to its armature. If a resistance be introduced into the armature leads, this will, of course, reduce the amount of voltage that is available at the armature, and reduce the speed. By the rule on page 1324, this motor, with a flux of 1,180,000 lines per pole, 930 conductors, 4 poles, 2 circuits, and a speed of 600 revolutions per minute, will generate a back voltage of $\frac{4}{2} \times \frac{600}{60} \times 930 \times 1{,}180{,}000 \div 100{,}000{,}000 = 220$ volts, equal (when the motor is running light, at top speed) to the voltage of supply. If load is put on the speed will drop a little, the back-voltage will drop correspondingly, and therefore automatically, and more current will flow from the mains to drive the load. At full load with this motor the speed drops to about 570 revolutions per minute, so that the back-voltage drops to about 210 volts. *By weakening the magnetism of the field magnets of the motor it will run faster; by strengthening it the motor will run slower.* This property is made use of to regulate the speed.

Starting of Motors. The current must not be turned on all at once on to a motor when it is to start. For when the armature is standing still it exercises no back volts, and there would be a rush of current several times greater than the proper full-load current, and the motor might be overheated or damaged. Consequently motors are arranged with *starting devices*, consisting essentially of arrangements of resistance wires on suitable frames with handles for moving contacts, by which various amounts of resistance can be first introduced into the circuit and afterwards cut out as the motor gets up speed.

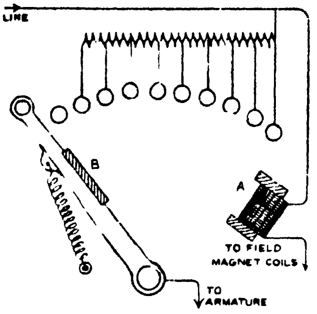
Fig. 95 represents diagrammatically a *starter* in common use. The current on its way to the magnet windings is taken round the coils of a small electromagnet at A, so that when the switch arm is moved to the full "on" position it is held there, against a spring, by attracting the soft iron armature B. Should the current fail to pass through the exciting circuit of the field magnet by any break of the connections, the electromagnet A at once releases its hold and the spring pulls the lever back to the "off" position, thus protecting the armature from any abnormal rush of current which might burn it out.

Sometimes motors are fitted with an overload release which automatically releases the controlling lever if the motor, by getting jammed, takes an excessive current from the mains.

96. MOTOR STARTER, WITH AUTOMATIC DEVICES FOR OVERLOAD AND NO-LOAD RELEASE
(British Thomson-Houston Co.

Fig. 96 depicts an actual motor-starting panel fitted with overload and no-load release devices. Many motors, especially those for lifts and large printing machines, are fitted with brakes to bring them quickly to rest when desired.

Variable Speeding of Motors. To enable a motor to operate at different speeds there are different devices. One of these is to introduce into the main path of the armature current more or less resistance. This reduces the voltage that is available at the brushes, and therefore, other things being the same, reduces the speed at which it tends to run. But this device is not economical, as it wastes energy in heating the resistance. In the case of shunt motors—that is, those having their field magnets excited in shunt circuit from the mains —it is usual to introduce a variable resistance into this shunt circuit, whereby the amount of exciting current, and therefore the amount of magnetism, can be reduced to raise the speed, or increased to lower the speed. This is an economical method, and is often combined with the former plan. In the case of series motors—that is, those having their exciting coils in series with the armature, the field-magnet coil can itself be shunted through a resistance to reduce the excitation and so raise the speed.



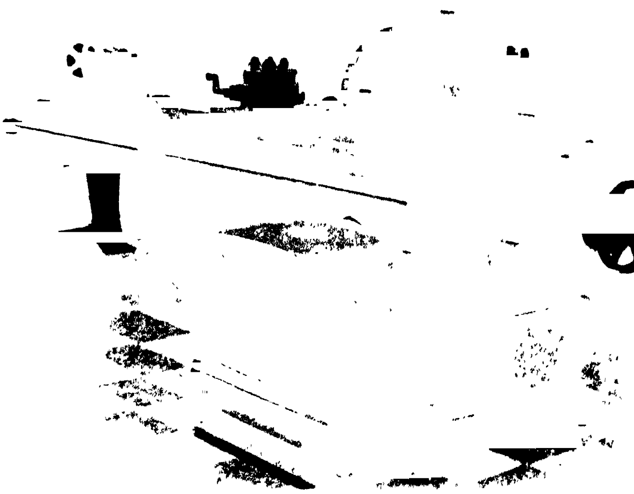
95. DIAGRAM OF MOTOR STARTER

Another plan often adopted in factory driving is to provide an electric supply with several sets of distributing mains at different voltages, so that the voltage applied to the armature of the motor can be altered at will. There is yet another plan—namely, to gear together two motors, which can be worked either in series or in parallel.

Motor Gearing. Frequently motors must be geared down in order that a small high-speed motor may be used instead of a large slow-speed one. An example of such gearing is shown in **97**, which represents the toothed wheels often applied to reduce the speed. Another example is afforded by **98**, which depicts a Tangye lathe driven by belt-gearing from a motor which itself runs at a higher speed than the lathe.

Motor Equipments. In the different trades the requirements of motors differ much. In the printing trade, for example, the motor which drives the printing-press must be able to run quite slowly—say at ten to fifteen revolutions per minute only—when making up or threading, but must run very quickly when in ordinary work. So, in such cases, there must be a special motor for each machine. On the other hand, in textile factories, where a very uniform speed of driving is required for the looms and spinning machines, it is common to find lines of shafting each driven by one large motor, while the individual looms are driven by belts from the shafting.

Motor Driving in Factories. In engineering factories, if each machine-tool be driven by a separate motor, the speed of each can be that best adapted for the particular tool. For milling cutters, planing machines, and slotting machines, the range of variation of speed is seldom greater than from 1 to 2; whereas on lathe-work much wider variations of speed are needed. When the lathe is used to turn up a wheel it must run slowly; when it is turning a shaft it must run quickly. Hence, electric driving with variable-speed motors has distinct advantages. Moreover, the long lines of shafting which used to be seen in all engineering factories waste much power in useless friction. By abolishing these, and putting electric motors to drive the various tools, a great saving in power can be effected.



98. TANGYE LATHE DRIVEN BY AN ELECTRIC MOTOR

Electric Cranes. So great are the advantages of the electric motor as applied to travelling cranes, that practically all travelling cranes now made for factories are driven by electric motors. Cranes for shipyards, docks, and railway loading are often now electrically driven. Motors for electric cranes are not required to run at a uniform speed; and as they are used intermittently, with periods of rest in between, it is usual to allow them to be designed with thinner copper conductors and smaller cross-sections of iron than are considered permissible in other motors. As a consequence they heat up more quickly when the current is switched on; but they have time to cool down again.

97. SPEED-REDUCING GEAR FITTED TO MOTOR
(Peebles & Co.)

Alternating Current Motors. For single-phase alternating currents motors can be used with commutators of design very similar to ordinary motors, but the whole of the iron parts must be laminated, except the external frame and bedplate; and special means must be adopted for securing sparkless commutation.

Continued

Group 5
CHEMISTRY
11

Continued from page 1448

THE LAWS OF COMPOUNDS

The Work of John Dalton and of Democritus, the First Atomist. The Preparation of Compounds. Water. Hydrochloric Acid. Ammonia. Salt

By Dr. C. W. SALEEBY

HAVING completed, so far as is possible, our discussion of the elements, but deferring our consideration of the most remarkable of them all—radium—which raises so many new questions, we now pass on to the study of compounds in general, and must discuss some of those simpler inorganic compounds which are of great importance, but have not hitherto been adequately dealt with. We have already discussed the difference between a compound and a mixture. We saw that a mixture, such as the air, consists of a number of molecules, each of which is composed of similar atoms, whereas the essential character of a compound is that it consists of molecules composed of dissimilar atoms, molecules in which the atoms of one element go about in the company of the atoms of one or more other elements. Our conception of the real meaning of the word "compound" depends upon our conception of the meaning of the word "molecule." Furthermore, we are already familiar with those formulas which express the number and kind of atoms that go to compose the molecules of certain compounds; while we have already noted the facts that when elements unite to form compounds, they do so in fixed proportions, that any given compound always contains the same elements in the same proportions, and that thus the most obvious fact which distinguishes a compound from a mixture —the fact from which the others have been inferred—is the fact of definite composition.

The Atomic Theory. The real meaning of all these facts was most clearly understood and formulated by John Dalton, who must be regarded as the modern founder of the atomic theory. We must insert the word "modern," because there was an illustrious Greek named Democritus, who flourished in the fifth century before Christ, whom we must regard as the first atomist; and his views upon the ultimate atomic structure of matter have received expression, which is secure of immortality, in the magnificent poem *De Rerum Natura* ("Of the nature of things"), written by the Roman Lucretius, who lived in the first century before Christ. But, of course, there is all the difference in the world between the splendid imaginative efforts of poets and philosophers and the scientific establishment of their theories. As has been very well said, "he discovers who proves." And from our standpoint as students of chemistry, it is necessary to pay much more attention to John Dalton than to Democritus or Lucretius, though we may be prepared to admit that their genius was in many ways incomparably superior to his. He it was, at least, who removed the atomic theory from the realm of speculation however brilliant or sublime, and established it as the logical basis of modern chemistry, which we may thus assert to be only a century old.

John Dalton. This remarkable man was born at Manchester, of a Quaker family, in the year 1766. By profession he was for some time a schoolmaster, but he is an instance of that type of mind which no circumstances can prevent from occupying itself with scientific inquiry. He studied plants and the weather, mathematics and physics, and turned to excellent account the infirmity of colour blindness, from which he himself suffered. So important was his study of this malady that it is often known as Daltonism. The great work of his life, however, was the product of his maturer years, and his "New System of Chemical Philosophy," which is a classic, began to appear in 1808, its chief theory having been propounded, however, in 1804.

Splitting the Atom. We have already seen that the atom can no longer be thought atomic, and that the smallest simplest, and lightest atom known is in reality a microcosm relatively as complex as the solar system. Hence, some critics have too hastily said that the whole structure of modern chemistry, founded by Dalton, has been swept away at a blow. That, however, is simply nonsense. Even though we have had to modify profoundly our conception of it, yet we are still absolutely certain that there is such an entity as the atom, which, like the solar system, has a unity of its own, and of which the facts asserted by Dalton are true, even though we can no longer regard the atom as indivisible. It is an admirable instance of unity in multiplicity. The name of Dalton, who died in 1844, has in no sense been deposed from its illustrious place in the history of chemistry, and his atomic theory, though necessarily modified, stands now upon a basis so firm that it can never be shaken. Having done some brief justice to this great genius, to whom more than to any other man, we owe the intelligibility of our subject, and having, thanks to him, a clear understanding of what is meant by a compound, even whilst remembering that the elements themselves can no longer be regarded as elementary, let us pass on to the consideration of compounds in general, the kinds of elements which notably form them, and the principles of their artificial preparation.

The Most Important Compounds. The most important compounds are composed of certain elements which may be named. In the first place there are the halogens—we will not pay the reader the poor compliment of naming them again—which, as the word implies, tend to form salts. Their compounds are called halides. Then there are the two elements which we treated together, oxygen and sulphur. simple compounds of which, with other elements, are called oxides and sulphides. Carbon also forms simple compounds with other elements, which are called carbides, whilst those of nitrogen and phosphorus are called nitrides and phosphides. The reader will observe the uniformity of the terms, which all end in "ide," and which indicate compounds consisting of the element in question with one other element. When we have double compounds, such as calcium carbonate $CaCO_3$, different terminations are employed; the compound is called, not a carbide, but a carbonate.

Preparation of Compounds. Countless compounds occur in nature, but these can be artificially prepared in the laboratory, and recent chemistry has also been able to prepare thousands of compounds which do not occur in nature at all.

The first and simplest method is obviously that of direct union—as, for instance, when, as we saw on page 692, oxygen and hydrogen combine under the influence of the electric spark to form water. The commonest instances of direct union are cases of oxidation, which has already been defined as combination with oxygen. As a rule, light and heat are produced when this occurs, and in such cases we apply the term combustion to the process. Very nearly all cases of combustion are oxidations.

(If the reader is also studying the course on PHYSICS, he will remember the doctrine of the conservation of energy ; he regards heat and light as instances of energy, and the doctrine teaches him that these are not created out of nothing during combustion. Where do they come from ? The answer is that they are the equivalents of the potential energy contained in the atoms of the combining elements before they combined—a potential energy which they no longer posess when their affinities for one another have been satisfied. It has left them in the form of light and heat. Compare what was said in a recent section of the general tendency of chemical processes.)

Combustion without Oxygen. But there are instances of combustion in which oxygen is not involved. Hydrogen, for instance, will burn in chlorine, and so will many other elements ; and, as we should expect, certain elements furnish instances of combustion with sulphur, which, in this respect again, thus resembles oxygen. The second instance we have already seen illustrated when we dealt with the preparation of elements. For when we turn an element out of one of its compounds, a process which we saw to be one of the recognised methods, we form a new compound. For instance, when sodium turns hydrogen out of water, sodium hydroxide (NaOH) is formed.

Compounds are also formed when other compounds are heated ; when, for instance, we heat calcium carbonate, which is a double compound, we get two simpler compounds, carbonic acid (CO_2) and quicklime (CaO). *Double decomposition* is the last method we need note, and a very important one. The name practically explains itself, and implies the change which occurs when two compounds exchange partners, so to speak. It is of use when one of the new substances produced is spontaneously separable from the other, either because it is volatile, and so passes off, or because it is insoluble, and thus separates in solid form, or is precipitated, to use the technical term. An excellent instance is furnished by the change which occurs when solutions of common salt and silver nitrate are mixed with one another. This is also of interest in explaining the fact that common salt, in virtue of this change, is the best antidote when silver nitrate has been swallowed. The formula of silver nitrate is $AgNO_3$, and we may regard the compound as consisting of two parts, one the metal and the other the group of atoms, NO_3. When this interacts with common salt, the formula of which is NaCl, partners are exchanged, the NO_3 group going with the sodium, and the chlorine with the silver. The chloride of silver formed is insoluble, and can be separated. Being insoluble when formed in the stomach by the administration of sodium chloride in a case of silver nitrate poisoning, it is harmless. The following equation represents the double decomposition :

$$AgNO_3 + NaCl = NaNO_3 + AgCl.$$

(Silver nitrate plus sodium chloride equals sodium nitrate plus silver chloride, insoluble.)

We may now consider some important compounds which demand separate treatment, and of these the first is the most important compound of all, *water.*

Water. This covers much more than half of the earth's surface, is contained in greater or less degree on what we call the dry land, occurs as ice and snow in many parts, is always present in greater or less quantity in the atmosphere [see PHYSICS], and in its liquid form is an essential constituent of all living things. Chemically considered, even an Aristotle or a Shakespeare is about four-fifths water, a fact which is of interest to the chemist, but also of interest as showing how ridiculously inadequate, from the point of view of the psychologist and the philosopher, is the merely materialistic estimate of man.

We have also seen that water occurs in abundance in a less obvious form as water of crystallisation in many crystals.

This compound may be prepared, as we have already seen, by the direct union of oxygen and hydrogen, and by others of the methods of preparing compounds mentioned above. Most of the remarkable physical characters of water have had to be discussed in the course on PHYSICS—such, for instance, as its freezing and boiling point, its remarkable specific heat, its peculiar behaviour in relation to its density at low temperatures, its latent heat, and its rôle in the atmosphere.

For the chemist, water is the almost universal solvent. There are very few substances indeed —solids, liquids and gases alike—of which a tiny proportion at least is not soluble in water, the rule being that solids are more soluble in hot than in cold water. The nature of hard and soft water was discussed under "Calcium" [page 844]. We saw in our first section that the discovery of the compound nature of water, regarded as an element since the days of the Greeks—since the dawn of thought—stands to the credit of Henry Cavendish, who made this most important discovery in 1781.

Hydrochloric Acid. This very important acid, to which we have made incidental references, may be compared with water, in that it is a compound of hydrogen with another element. Its formula is HCl, only one atom of hydrogen being necessary for one atom of chlorine, each of these elements being one-handed or monovalent. We are very apt to think of hydrochloric acid as a liquid, but it is really a gas somewhat heavier than air, and is often looked on as a liquid because it is extremely soluble in water, which is able to dissolve seven hundred times its own volume of this gas. An older name for hydrochloric acid, still quite frequently seen, is muriatic acid. The gas is occasionally found in nature near volcanoes, but this source is of no practical importance. It may be prepared in many ways—such, for instance, as the direct union of gaseous hydrogen and chlorine, or by the action of sulphuric acid on common salt. This is an instance of double decomposition. The following is the equation that represents it:

$$NaCl + H_2SO_4 = NaHSO_4 + HCl,$$

the hydrochloric acid being given off as a gas, and the acid salt called *acid sodium sulphate* or *hydrogen sodium sulphate* ($NaHSO_4$) being formed. We may make a mental comparison between the formula of this salt and that of what we may call normal sodium sulphate (Na_2SO_4). The acid salt is so called because, as the reader will see, only one of the hydrogen atoms of the sulphuric acid has been replaced by sodium in the molecule of the acid salt.

Hydrochloric acid, in the form of its solution in water, is a very powerfully acid and corrosive liquid, having the typical properties of an acid. It is largely made as a preliminary to the making of sodium carbonate or washing soda. The acid is a powerful antiseptic, but is used for this purpose only within the human stomach. It is an extremely remarkable fact that this potent acid may be regarded as one of the natural antiseptics of the body, which produces it for itself, as we shall now see.

Hydrochloric Acid in the Stomach. Hydrochloric acid is a constant and necessary constituent of the juice of the stomach, in which it plays two very important parts. The first, which is generally recognised, is to aid in the digestion of the most important kinds of food stuffs, which are called proteids. The second, the importance of which is only now beginning to be appreciated, is to act as an antiseptic. It has been shown that there are many kinds of diseases, the microbes of which cannot survive in gastric juice, and which can attack us only by entering the body elsewhere, as through the lungs, or passing through a stomach which is out of order.

But these are matters hardly of chemistry. The really amazing fact for the chemist is the mode of production of this acid by the wall of the stomach. Its source, as in the ordinary commercial process, is sodium chloride ($NaCl$). This is one of the firmest and most stable compounds that we know. In order to decompose it and form hydrochloric acid the manufacturer finds it necessary, in the first place, to employ the most powerful of all known acids—sulphuric acid—and in the second place to use great heat, so as to permit of the decomposition.

Chemical Power of Living Cells. But in the human body there is no sulphuric acid, nor is there anything like the heat which the manufacturer employs, yet such is the potency of the living cells in certain of the glands in the wall of the stomach that, in some way which we have not yet begun to understand, they are able to decompose this firm compound, sodium chloride, without the use of any potent acid and at the mere temperature of the blood. This decomposition seems to the writer to be, perhaps, the most amazing of all proofs of the chemical power of the living cell. The proof of this power that is most often quoted is the remarkable decomposition of carbonic acid (CO_2) in the atmosphere by means of the living cells of the green leaf—a decomposition which was referred to when we were discussing the future of the atmosphere and the rôle of carbonic acid in it. The necessary agent in this decomposition is the green matter found in the cells of the leaf, which is called *chlorophyll*. Now, carbonic acid is a compound even firmer than sodium chloride, and the temperature at which the leaf decomposes it is far lower than that of the blood. Hence it would appear as if this decomposition were more remarkable than the formation of hydrochloric acid in the stomach. It looks as if the chlorophyll of the leaf were to be regarded as a sort of ferment—one of those extraordinary substances which have the power of producing chemical change, though themselves remaining unchanged. But Sir James Dewar, in conversation with the writer, observed that this is not the way in which we should look upon chlorophyll; rather should we regard it as a means of condensing or, to use an excellent metaphor, focussing the sunlight which—and not the chlorophyll—is the essential factor in the process.

The Energy of Sunlight. The energy by which this firm compound, carbonic acid, is decomposed is thus the tremendous energy of sunlight, suitably utilised, adapted, condensed (whatever word we may use to veil our ignorance) by means of the chlorophyll of the living cell. In the case of the decomposition of the sodium chloride in the cells of the stomach, however, sunlight is neither available nor necessary. The work is effected, not by the transformation or utilisation of the solar energy, but by means of the mysterious energies which are proper to the living cell itself. Therefore we think that this decomposition, with its ease, its lower temperature, and the absence of any visible decomposing agent such as sulphuric acid, as compared with the means which the manufacturer has to employ, may be regarded as perhaps the most signal instance of the possession of such powers by the living cell.

Ammonia. Here, again, as in the case of water and hydrochloric acid, is a simple compound of hydrogen with another element, in this case nitrogen, the formula of ammonia being NH_3, as was mentioned when we discussed nitrogen. In the case of water the hydrogen was combined with a two-handed element, so that, itself being one-handed, two of its atoms were required in order to unite with one of oxygen; in the case of hydrochloric acid the united element was also one-handed, and in the case of ammonia we find that the united element is to be regarded as three-handed, or trivalent. This substance, like the last, is a gas at ordinary temperatures, colourless, but by no means odourless. Its effects upon the nose, however, are not confined to the stimulation of the sense of smell. Its pungency should be distinguished as composed of two parts, one consisting of its irritation of the ordinary sensory nerves of the nose—as of any part of the body to which it gains access—and the other consisting of a true stimulation of the nerves of smell. The gas is lighter than air, and is even more soluble in water than is hydrochloric acid. The solution, which is often loosely called ammonia, indeed contains as much ammonia as is equivalent in volume to about eight hundred times the volume of the water in which it is dissolved, the exact proportion varying with the temperature [see PHYSICS]. The solution has all the characteristics of an alkali, and, indeed, ammonia is commonly called the *volatile alkali*, since, being essentially a gas, and therefore volatile, it is contrasted in this respect with soda, potash, and lime, which are called *fixed alkalies*. We have, indeed, good reason to assume that, when ammonia gas is dissolved in water, something rather more than mere solution occurs. There is doubtless some sort of combination between the ammonia and the water—certainly a very unstable combination, but still more than a mere solution; and we may conveniently represent what happens by adding together the formula of ammonia and the formula of water, thus:

$$NH_3 + H_2O = NH_4OH.$$

Ammonium. When we look at the formula of this supposed substance, writing it in the fashion seen, and not in the most obvious way, which would be NH_5O, there is suggested to us a parallelism between this and the formula of soda, or lime, or potash. The latter, for instance, is KOH, and the K corresponds to the NH_4. Now this NH_4 seems to be such an independent reality that it has been given the special name of ammonium, and must probably be regarded as a metal. The reader will answer that it is absurd to talk about a compound of two gases as a metal—"Why, it is not even an element!" he may say; but, then, all our ideas of elements have undergone a change, and if the existence of the compound metal ammonium was probable ten years ago, it is still more probable to-day. In theory its existence is extremely probable, and the parallelism between its compounds and those of the other metals is most marked. There is, indeed, a small amount of evidence in favour of the view that the transient existence of ammonium in its metallic form has been experimentally demonstrated.

What we must probably regard as an ammonium amalgam—that is to say, a probable combination of the metal ammonium and the metal mercury—is a butter-like metallic mass which is produced when sodium amalgam (a white substance made by mixing sodium and mercury) acts on a strong solution of ammonium chloride (NH_4Cl) [compare KCl]. This amalgam, however, is, as might be expected, very unstable, doubtless owing to the instability of the supposed ammonium, and quickly decomposes into mercury, ammonia, and hydrogen.

It may possibly be a combination of low temperature and high pressure, at which ammonium is stable; and the fact of its decomposition by no means excludes the possibility of its existence as a true metal, since we now have definite proof of the decomposition of various metals, such as uranium, radium, and most probably silver, if not yet gold.

Gaseous ammonia forms a colourless liquid at a temperature of about $-33°$ C., and freezes at $-75°$ C.

Sources and Preparation of Ammonia. Small quantities of ammonia occur in the air, whence some of the compound is carried by rain into the soil and rivers. The occurrence of ammonia in the soil is of the utmost importance in relation to plants. As we saw when discussing nitrogen, this element is a constituent of protoplasm, the physical basis of life; and the plant has to obtain it from the soil. The form in which the plant obtains its nitrogen is mainly in the compounds—salts of nitric acid—which are called nitrates. Now it has been discovered that the ground contains a particular kind of microbe or bacteria [see BACTERIOLOGY] which play an all-important part in this connection, and which are thus to be regarded, humble though they be, as a necessary link in the chain of events upon which human life itself depends. For it is from plants that all animals derive their necessary nitrogen. These organisms take the ammonia of the soil, and with the aid of oxygen, which is abundantly present in its elemental form in the soil air, and also in combination, they convert it into nitric acid (HNO_3). This typical acid reacts with the typical alkali, lime, which occurs in the soil, and forms calcium nitrate, in which form the plant thus obtains its nitrogen.

Ammonia from Decomposition. Ammonia is also formed by the decomposition of animal and vegetable matter. Certain salts of ammonium may be obtained in a similar fashion. Amongst these is sal-ammoniac—the old name for ammonium chloride—and also the carbonate of ammonium $(NH_4)_2CO_3$, which is usually known as smelling-salts or spirits of hartshorn, a name which hints that it may be obtained by distilling the horns of stags.

In addition to these more or less natural sources, ammonia may be obtained by the direct union of hydrogen and nitrogen, provided that one or other or both be in the nascent state, which we fully explained in an earlier section. But the most common method of preparing ammonia is by double decomposition—sal-ammoniac being heated with quicklime, with the formation of calcium chloride, which is highly soluble in water, whilst ammonia gas is liberated, and, being lighter than air, may be collected by an inverted vessel placed above it. The following equation represents the reaction:

$$2NH_4Cl + CaO = CaCl_2 + H_2O + 2NH_3.$$

Ammonia and the Alkaloids. Ammonia has extremely marked and important reactions in relation to living matter, upon all forms of which it acts as an irritant and a poison. Properly administered it is a stimulant, as everyone who has used smelling-salts knows. It is the most powerful and rapid of all known stimulants of the heart and lungs, whose functions are the most important for life, and it is, therefore, of superlative value in emergencies, especially as its physical form enables the patient to breathe it and thus to obtain its action even more quickly than in the case of a liquid stimulant injected under the skin. The behaviour and structure of ammonia are also of great interest in the more obscure regions of chemistry, because of the existence of a very large and important class of substances called *alkaloids*. These are mainly produced by plants, and include such extremely potent drugs as morphia and strychnine. They are called alkaloids in order to indicate their resemblance to alkalies. (The determination "oid," so often seen in scientific and philosophical language, is Greek, and implies likeness. In this, and in every other case, it suggests that the substance in question is not exactly the same as the other, but strongly resembles it.) Now there is good reason to believe that it is the presence of ammonia in the molecule of these alkalies upon which their alkaline properties depend. Thus we are not at all surprised to learn that all alkaloids contain nitrogen and hydrogen.

Marsh-Gas. At this point we might proceed to discuss another simple compound of hydrogen with another element, in this case the four-handed element carbon. This compound is known as *methane*, or *marsh-gas*, and has the formula CH_4, but it is probably better discussed later, since its properties serve as an admirable introduction to the study of a very large number of compounds in organic chemistry or the "chemistry of the carbon compounds."

In dealing with the most important elements with their properties in sequence, and in thereafter returning to the consideration of their important compounds, we have adopted a plan, of which one of the advantages is this, that the student can scarcely be successful in his study of compounds unless he has already learnt the main facts of the elements of which they are compounds. This necessity would not obtain if we took up each element and its compounds together.

Compounds of the Halogens. In proceeding, then, we assume that the reader is already familiar with, at any rate, the outstanding facts of the elements, and the first group of compounds to which we shall refer are those of the halogens, which were discussed in their turn in a recent section. The acids which correspond to hydrochloric acid are much less important, and need not further be discussed, or even named. But there is one pre-eminent compound which demands careful treatment.

Common Salt. We are already familiar with the technical name of common salt, which is sodium chloride (NaCl). It is an extremely abundant compound, constituting from 3 to 5 or 6 per cent. of sea-water, a much higher percentage of the waters of certain salt lakes, such as Salt Lake in America, the Caspian, and the Dead Sea, and also occurring in immense deposits in various parts of the world, where it indicates the past existence of salt lakes which have dried up. When it is obtained by the present evaporation of sea-water it is often called *bay salt*, whilst the deposits depending upon past evaporation are called *rock salt*. It may be mined, or the deposits may be flooded and pumped up as brine, which is then evaporated, or (as still, in many parts of the world) it may be obtained by the evaporation of sea-water. It forms cubical crystals which melt at a high temperature, and is readily soluble in water, being more soluble in hot water than in cold. Its artificial composition is thus superfluous, but it might be obtained by burning sodium in chlorine gas, or by the action of hydrochloric acid on sodium or on caustic soda or on sodium carbonate.

Salt and Life. Salt, being a necessary article of food, has played a part in many ceremonies of many ancient peoples, and has very frequently been taxed. We tax it in India today to some extent; but it should be recognised that a tax on salt is a tax on food, and in hot countries, such as India, where salt, which has mild antiseptic properties, is extremely necessary, not only for itself, but as a means of preserving fish and other food, the propriety of a salt tax is, to say the least of it, dubious. Recently, the great surgeon Mr. Jonathan Hutchinson, who believes that in India and elsewhere leprosy is caused by the eating of putrid fish, succeeded in persuading Lord George Hamilton to reduce the salt tax; but whether or not Mr. Hutchinson is right, any Government which draws a revenue from this substance—we are by no means the only offenders—is open to very grave criticism.

Salt and Food. The proportion of salt that occurs in different foods varies widely. In general, salt has to be added to the diet of the vegetarian, man or animal, while the meat eater obtains enough in the muscular tissue which he consumes. The imperative necessity of salt for life is illustrated by the extraordinary account of the wild flights of herbivorous animals in

America, long deprived of an adequacy of salt, towards salt-licks, or places where they can satisfy themselves by licking deposits of sodium chloride.

The saltness of the sea is a fact of the utmost interest in relation to the history of the earth. If we discuss all the salts of the sea in general, we find that they are carried down to it by rivers and streams, which dissolve them from the soil and land through which they pass. As the sea-water evaporates, the salts are left behind, and thus they accumulate—the sea is becoming salter every day. This fact has lately been utilised, not without success—that is to say, agreement with results obtained by other methods—in an attempt to estimate the age of the earth's crust from the present saltness of the sea and the probable rate at which addition is being made to its saltness.

Carbon and Chlorine. Another halide which is of great interest on theoretical grounds—though it is of no practical importance—is called carbon tetrachloride, and has the formula CCl_4. Its interest depends upon its relation to methane or marsh-gas (CH_4), already mentioned. For if this be exposed to the action of chlorine, atoms of this gas successively replace atoms of hydrogen, hydrochloric acid being meanwhile formed. The substances which are produced have the formulas (starting from marsh-gas CH_4), CH_3Cl, CH_2Cl_2, $CHCl_3$, ending with carbon tetrachloride CCl_4. The body produced when three atoms of hydrogen have been replaced is chloroform. As we might expect, remembering their chemical resemblance, its two predecessors have similar properties, and are occasionally used in surgery. Carbon tetrachloride also has antiseptic properties, but it is not of practical use.

The Halides of the Nitrogen Group. The nitrogen group, consisting of nitrogen, phosphorus, etc., forms a series of compounds with the halides, but these are not of great importance. The best known are the trichlorides, such as nitrogen chloride (NCl_3), phosphorus chloride (PCl_3), etc., whilst phosphorus and antimony also form what are called pentachlorides, such as PCl_5, phosphorous pentachloride, in which the phosphorus is, so to speak, five-handed.

Final Note on Halides. The other halides that are of sufficient importance have been dealt with already. It is well to remember a general rule which the halogens follow in replacing one another in their compounds. In the case of the salts of sodium and potassium, at any rate, chlorine will turn out bromine and iodine, and bromine will turn out iodine.

It is also well to remember the names of the insoluble or practically insoluble chlorides, because the fact of their insolubility takes us a long way in identifying the base which goes to compose any unknown salt in solution, the nature of which it is desired to ascertain. Supposing that an unknown solution of a salt be handed to us, the addition of hydrochloric acid will, in the large majority of cases, cause the formation of a chloride, and if the metal be silver, lead, mercury, or copper, this will be precipitated, since the chlorides of silver and lead and mercurous and cuprous chloride are insoluble.

Continued

Group 25

PHYSIOLOGY

11

Continued from page 1423

FRAMEWORK OF THE BODY

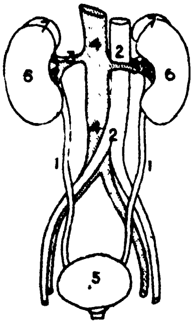
Kidneys and Their Work. Position and Form of the Bones of the Cranium, Face, Neck, and Trunk. How the Backbone is Built up

By Dr. A. T. SCHOFIELD

HERE we reach the third of the great excretory organs of the body (in addition to the bowels), which are the lungs, the skin, and the kidneys. The lungs specially excrete the gas CO_2 ; the skin, the *liquid*, water ; and the kidneys (in addition to the water), the *solid*, urea. These are all true excretions, and the three organs are, therefore, specially associated together, as three men might be, labouring at one piece of work. If any one of the three is partially or wholly disabled it throws more work upon the other two. In consumption, for instance, if a large part of the lung is destroyed, the skin and kidneys have to do the work. With a dirty skin more work is thrown on the lungs and kidneys, while in diseased kidneys the skin has to be very active.

The Kidneys. The kidneys are two bodies shaped like beans situated at the inner side of the lower ribs, close beside the spine [74], the right being the lower of the two. Each one is 4 in. long, 2½ in. broad and 1 in. thick, and weighs 4½ ozs.

From each kidney a tube like a small india-rubber pipe, called a *ureter*, from 12 to 16 in. long, leads down to the bladder, which is a single central organ like a bag, containing the excretion of the kidneys, called urine. From this bladder a short tube called the *urethra* enables the urine to be excreted. The construction of the kidneys is as follows : Each is covered with a fibrous skin called a *capsule*. Inside this the substance of the kidney divides itself into three—the outer part, or *cortex*, which is deep red; the *medullary*, which is paler; and the innermost hollow part, called the *pelvis*. The first is one-third of the thickness of the kidney, the second one-half [75].



74. THE KIDNEYS AND BLADDER

1. Ureters
2. The abdominal aorta
3. Renal veins and arteries.
4. Inferior vena cava
5. Bladder
6. Kidneys
7. Suprarenal capsules

Their Structure. The principal structures in the cortex are the *Malpighian corpuscles*. The kidney itself is a compound tubular gland, and the medullary part is almost exclusively composed of tubes. These ascend into the cortex at intervals and terminate in dilated extremities called Malpighian corpuscles; or, rather, the tubes may be said to start here, and after pursuing a very devious course for some 2 in., terminate and discharge their contents from tiny orifices in each of the 12 pyramids which project from the medullary part into the pelvis, where all the urine thus discharged collects and eventually leaves the kidney from the hilum by the ureter. There are 30 to 40 orifices in each pyramid that discharge urine, and the number of corpuscles whence it is obtained from the blood are about half a million in each kidney.

Each urinary tubule actually begins in the cortex by a deep cup-shaped expansion or capsule, that embraces a little tuft of capillary blood-vessels like a raspberry, the whole being $\frac{1}{125}$ in. in diameter [76].

Their Blood Supply. The blood supply of the kidney is peculiar. It arrives by the renal artery direct from the aorta; the arteries form regular arches at the junction of the cortical and medullary portions in the substance of the kidney. From these arches branches ascend into the cortex of the kidney, having at each side those expanded tufts of blood-vessels which form the Malpighian corpuscles. The artery suddenly breaks up into this cluster of capillaries, and seems to have pushed before it the dilated end of the urinary tubule, so that two layers of it become wrapped round the blood-vessels, leaving just room for the two vessels that form the stalk.

Here, then, the water of the blood that forms the liquid part of the urine is strained off after the manner of a filter.

The Work of the Kidneys. There still, however, remain in the blood the urea and other waste products which are not to any extent got rid of in the lungs. The blood, purified there of its carbonic acid gas, comes straight to the kidney after leaving the heart, and having first lost its superfluous water, has urea and other substances extracted from it in another part of the urinary tubules. It must be remembered that the tubule, originating in the Malpighian corpucles, pursues a very devious course, during which it is closely surrounded by blood-vessels, from which it is believed, by the vital action of the urinary cells, the various substances are extracted [77].

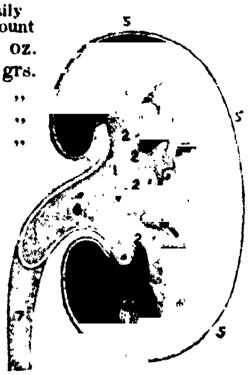
The blood, thus purified of all remaining impurities, returns by the renal veins to the inferior vena cava; and differs totally from all other venous blood in being bright red and actually the *purest blood in the body*. It must be remembered one artery carries venous blood, the pulmonary, and two veins carry arterial blood, the pulmonary and the renal.

All the tubules uniting pour their contents into the pelvis of the kidney, and the fluid is called urine.

It is a transparent, acid, amber fluid and is heavier than water, its sp. gr. being about 1020 as compared with 1000. About three pints are produced each day.

The following is its chemical composition:

	Per Cent.	Daily Amount
Water	95·5	52 oz.
Urea	2·4	500 grs.
Uric Acid	1·0	36 ,,
Salts	·9	400 ,,
Extractives	·2	153 ,,
	100·0	



75. LONGITUDINAL SECTION THROUGH LEFT KIDNEY

1. Sinus 2. Papillæ opening into the calices
3. Pyramids of Malpighi
4. Cortical substance
5. Capsule 6. Pelvis 7. Ureter

The colour varies through every shade of yellow and orange. It is only brown or black in disease.

The urine is acid in health and becomes more so when acids are taken, also after prolonged exertion or consumption of much animal food.

It becomes less acid or alkaline when alkalies are present, after taking much vegetable food, after sweating profusely, or long standing after it is passed.

Weight and Quantity. Its weight compared with water varies considerably; much drinking may temporarily lower it to 1002, while taking no fluid, and profuse perspiration, may raise it to 1040. Some diseases increase and others lower its specific gravity. If the last two figures of the specific gravity be doubled it gives the amount of solids in 1,000 parts. If the sp. gr. of urine be 1025, then 25 × 2 gives 50 parts solids in 1,000.

The quantity of urine varies greatly. It is decreased by sweating, by eating dry food, by bleeding, and by disease. It is increased by cold, by dry skin, by the use of drugs, by sugar in the urine, and by nervous excitability.

Urea is the principal constituent of the urine, and represents the nitrogenous refuse of the body. It forms half of all the solids in the urine. It is a compound of water, carbonic acid, and nitrogen. As a rule, 500 grains a day are passed, and the amount of nitrogen passed is in proportion to the amount taken in the food. It is not increased by muscular exercise, as was formerly supposed, nor by the amount of urine, but by animal food and wasting diseases. Urea forms $\frac{1}{10000}$th part of the blood and $\frac{1}{2000}$th part of the lymph, showing how much impurer the latter fluid is of the two.

Uric acid is a similar nitrogenous product, but differs in one most important particular; for while urea is soluble and thus gives no trouble in the system, uric acid is insoluble, and is the source of many bodily ailments, notably gout.

In the urine it appears as a brick-red powder.

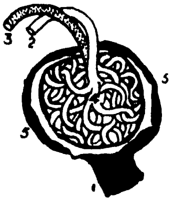
It is probable that urea and uric acid are not formed in the kidney as bile is formed in the liver, but in the blood, and are only eliminated by the kidneys. If the supply of bile from the liver be stopped, none is made; but if the kidneys do not act, an increased amount of urea is found in the blood. The secretion of urea and the amount of sweat are in inverse proportion, showing the close connection between the kidneys and the skin. A child excretes, in proportion to its weight, twice as much urea as an adult.

The ureter, about 15 in. long, is a strong tube of four coats, one muscular; it conveys the urine to the bladder by peristalsis, or circular contraction of the muscles, by gravity, and by the *vis a tergo*, or pressure from behind. It enters the bladder by a valve through which the urine trickles drop by drop. The bladder has also four coats and many elastic fibres, which keep it in a state of moderate contraction. It holds about a pint, and can be emptied at will.

THE LOCOMOTIVE MECHANISM

In considering the locomotive system we have to examine first its structure, and then its function.

It is composed of bones, joints, and muscles, and while describing these with sufficient fulness to be clearly understood, all needless details will be omitted, and technicalities avoided.



76. A MALPIGHIAN CORPUSCLE

Where the water of the urine is strained off

1. Urinary tubule
2. Artery 3. Vein
4. Capillaries.
5. Expansion of tubule squeezing capillaries

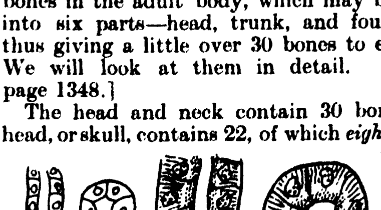
The Bones. We begin with the bones, concerning which a few words have already been said in an earlier chapter in speaking of the body as a whole, and we shall not, therefore, here repeat details of the information.

Bones are the framework of the body. They support the soft parts and protect the various organs. Here are shown the skeletons, for comparison, of man and the highest anthropoid ape—the differences are apparent [**78, 79**].

The organs of most importance are well guarded from injury, such as the *brain* by the *skull*, the *spinal cord* by the *spine*, the *eyes* by the *orbit*, the *heart* and *lungs* by the *chest-wall*.

We have pointed out that there are about 200 bones in the adult body, which may be divided into six parts—head, trunk, and four limbs—thus giving a little over 30 bones to each part. We will look at them in detail. [See also page 1348.]

The head and neck contain 30 bones. The head, or skull, contains 22, of which *eight* make up the cranium, or skull proper—the part that contains the brain—and *fourteen* the face. Only one of these 22 can move, and that is the lower jaw-bone, which is seldom still.



77. KIDNEY TUBULES

Where urea is extracted (sections)

1. Part secreting urea 2. Other part of tubule

Bones of the Cranium. The eight bones that make up the cranium are only separate in the young child's head, where their edges lock closely together with teeth, like a saw.

By degrees, the bones grow together, so that in the adult they cannot be separated any more; only the lines where they are joined can still be seen; they are called sutures, because they look just as if the bones were sewn together. The reason they are separate at first is to allow the brain to grow to its full size, and they then unite together to protect it more thoroughly.

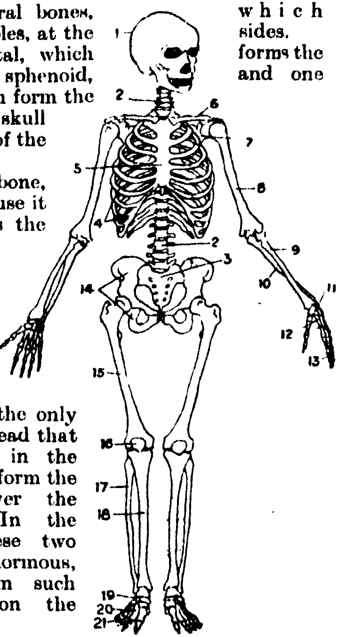
The eight bones are as follows [80]:

One frontal bone, which forms the forehead.

Two parietal bones, which form the vault.

Two temporal bones, which form the temples, at the sides.

One occipital, which forms the back. One sphenoid, and one ethmoid, which form the base of the skull and the back of the face.



78. SKELETON OF MAN
1. Skull 2. Vertebral column 3. Sacrum 4 Ribs 5. Sternum 6. Clavicle 7 Scapula 8. Humerus 9. Radius 10. Ulna 11. Carpus 12. Metacarpus 13. Phalanges 14. Pelvis 15. Femur 16. Patella 17. Tibia 18. Fibula 19. Tarsus 20. Metatarsus 21. Phalanges

The frontal bone, so called because it is in front, is the shape of a large cockle or escallop shell, and forms the front of the head and the top of the orbits. It is the only bone in the head that contains air, in the two cells that form the elevations over the eyebrows. In the elephant these two air-cells are enormous, and give him such big bumps on the forehead.

The parietal bones (Latin *paries*, a wall) form a great part of the dome of the head.

The temporal bones are so called because they form the temples. Temple comes from Latin *tempus*, time or age, and is so named because the hair first turns grey there in old age.

The occipital bone is so named from Latin *occiput*, the back part of the head. This bone connects the rest of the cranium with the top of the backbone, or spine, and has a large hole in the bottom of it through which the spinal cord (or marrow) passes out of the brain.

The sphenoid, or wedge bone, forms the front of the floor of the cranium, and is in shape like a flying bird.

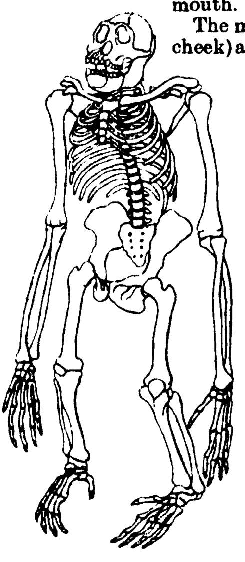
The ethmoid, or sieve bone, is placed below the frontal bone at the back of the face. It is called a sieve because it is pierced with many small holes, to allow the fine nerves of smell to pass through.

Bones of the Face. In the face are 14 bones, all in pairs (right and left), except two. They are:

Two superior maxillary, or upper jawbones.
Two palatal bones (in the mouth).
Two malar, or cheek bones.
Two nasal, or nose bones.
Two lachrymal, or tear bones.
Two turbinated, or nostril bones.
One vomer, or partition between the nostrils.
One inferior maxillary, or lower jawbone, the only one that moves.

The superior maxillary bones are so called from Latin *maxilla*, a jaw. In them the upper teeth are set. They form the front of the roof of the mouth or *hard palate*, and the sides of the nose.

The palate forms the back of the roof of the mouth.



79. SKELETON OF GORILLA
For comparison with human skeleton

The malar bones (Latin *mala*, cheek) are the cheek bones, and form the hard ridge under the cheek, and also the lower part of the *orbits*, in which the eyes are set.

The nasal bones (Latin *nasus*, nose) form the bridge of the nose.

The lachrymal bones (from Latin *lachryma*, a tear) conduct the tears from the eyes into the upper part of the nose.

The turbinated bones (from Latin *turbo*, a scroll) are rolled round in the shape of a scroll of paper, and form the inside of the nose, and the organ of smell.

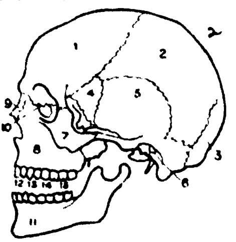
The vomer (from Latin *vomer*, a ploughshare) helps to form the bridge of the nose.

In the inferior maxillary bones are fixed all the lower teeth.

Thickness of the Skull. The cranium varies greatly in thickness in different parts. Where it is most exposed to injury, as on the top and forehead, it is thickest, the bone being often ½ in.; whereas, in the temple, just in front of the ear, it is not thicker than paper in one part. The special structure of these flat bones of the cranium serves to protect the brain from shock. They are made of two flat plates, with a network of spongy bone between. This arrangement prevents the shock of blows on the head (if not too violent) from reaching the brain. This you can prove by putting two flat pieces of wood (one on the other) in the hand; if you strike the upper piece, you can feel the shock in your hand. But if you now put a piece of soft flannel or felt between the two—like the spongy tissue between the bony plates—and strike the upper wood, you feel nothing, because the vibration is stopped.

The vaulted shape of the cranium gives it also great strength. No parts of the body are protected so carefully as the brain and spinal cord.

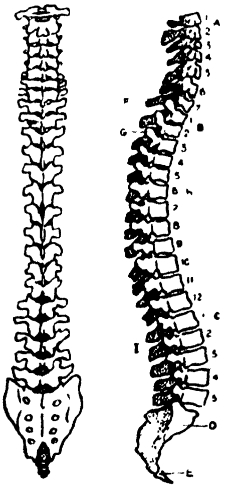
Bones of the Neck. In the neck there are eight bones, of which seven form the upper part of the spine or backbone, and the eighth is a bone in the throat, which can be felt beneath the lower jaw. It is the hyoid bone, or bone like a "U," because it is just the shape of one, with the round part forward. It supports the upper part of the windpipe.



80. THE HUMAN SKULL
1. Frontal bone 2. Parietal bone 3. Occipital bone 4. Sphenoid bone 5. Temporal bone 6. Styloid process 7. Malar bone 8. Superior Maxilla 9. Nasal bone 10. Lachrymal bone 11. Inferior Maxilla 12. Incisors 13. Canine teeth 14. Bicuspids 15. Molars

Bones of the Trunk. In the trunk there are 30 bones, if the ribs are counted in pairs—17 vertebræ in the back, 12 pairs of ribs at the sides, and one breast-bone, or sternum, in front.

The trunk is divided into the *chest* and *abdomen*. The chest or thorax is a bony cage formed by the spine behind, the *ribs* at the side, and the breast-bone in front, and contains the lungs and heart. The abdomen has only the spine behind, and no bones in front.



Back View Side View

82. THE SPINE
A. Seven cervical vertebræ
B. Twelve dorsal vertebræ
C. Five lumbar vertebræ
D. Sacrum E. Coccyx
F. Spinous processes
G. Transverse processes
H. Backward curve from breathing I. Forward curve from walking

The Vertebræ. The backbone, or spine, [82] is made up altogether of 33 vertebræ or turning bones, because most of them can turn a little on their own axis.

The first seven form the neck or cervical vertebræ; the next twelve form the back or dorsal; the next five form the loins or lumbar; the next five are united into one bone called the sacrum, or sacred bone.

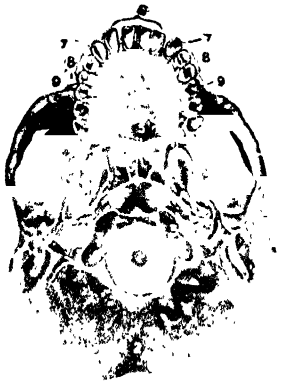
The last four are also joined into one bone called the coccyx, or cuckoo bone, and these two form the back of the hips.

These vertebræ are placed one on the top of another, like so many bricks, and each one is separated from the next by a stout pad of cartilage or gristle, which, like the spongy bone between the two hard plates of the skull bones, prevents any shock or jar from reaching the brain.

Although the spine contains 33 vertebræ in man, we see that five and four are joined together; and thus there are only 26 separate bones. In the child, on the other hand, each vertebra is made up of several separate parts, so there are nearly 200 pieces of bone to form the 33 vertebræ.

Shape of a Vertebra. A vertebra is something like the figure eight [83], with one of the circles made solid in front, and the other one left open and forming a ring behind; so that when all the bones are placed on one another, the solid discs in front form a bony column, and the rings behind form a long tube. The column supports the body, and the tube contains the *spinal cord*, or *marrow*.

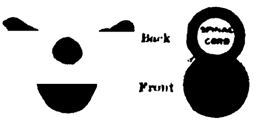
The ring behind has three bony projections, one on each side (transverse process), and one behind (spinal process), and it is the tips of those processes, one below another, that are felt as ridges of the spine behind. They are for the attachment of the strong muscles which support the long column called the spine.



81. BONES OF THE SKULL AND FACE FROM BELOW
1. Foramen magnum for the spinal cord 2. Occipital bone 3. Articular surface of the first cervical vertebra (Atlas)
4. The temporal bone 5. The vomer
6. Incisors 7. Canine teeth
8. Bicuspids 9. Molars

Use of the Padding. If we put 26 reels of cotton on the top of each other, with a soft pad between each for the cartilage, we can see how easily a little pressure from above would force the column to one side or the other. The pads prevent friction and jarring. The spine is only kept straight by exercising its muscles, and girls especially should have as much drill and exercise as possible, to strengthen this spinal column. The spine is naturally bent backwards in a curve which makes the beautiful spring on which the head is poised.

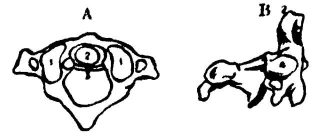
The Atlas. The top vertebra of the seven in the neck is called the *Atlas* [84 A], as it supports the head, just as the fabled Greek god Atlas carried the heavens on his shoulders. It consists of a strong bony ring, divided in two by a fibrous band. On the upper surface are two smooth sockets, on which the lower part of the occipital bone



83. A VERTEBRA RESEMBLES THE FIGURE EIGHT

of the skull rests, and on which the head moves backwards and forwards, as when we nod and say "Yes." Through the back part of the ring the spinal cord passes into the brain by the great opening in the occipital bone.

The Axis. The second vertebra is called the *Axis* [84B], because in front of it is a strong bony peg about an inch long passing up through the front of the ring of the atlas, and on which it and the head can turn from side to side, as when we shake the head and say "No."

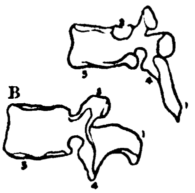


84. ATLAS AXIS
1 and 4. Articulation 2. Peg, or Odontoid process 3. Ligament

Meaning of a Broken Neck. If this peg breaks through the fibrous band across the atlas, as in hanging, it presses on the spinal cord behind, and causes instant death, and the person is said to have his neck broken.

To see how this is done, make a ring with the first finger and thumb of the left hand, and then tie a thread to stretch across it from the middle of the finger to the middle of the thumb; then put the forefinger of the right hand up through the front division to represent the peg of the axis, and put your thumb through the other division to represent the spinal cord. If you then break the thread by pushing backwards with the right forefinger, and press on the thumb, you see exactly how a man's neck is broken.

The other vertebræ are all pretty much alike, only the lower they go down the larger and stronger they become in every way [85], until the last of the twenty-four rests upon the *sacrum*, which forms the back of the hips.



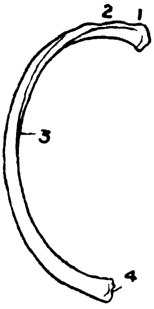
85. A. DORSAL VERTEBRA. B. LUMBAR VERTEBRA
1. Spinal process
2. Articulation
3. Lateral process
4. Inferior articulation
5. Body

The Ribs. The Ribs [86] are long bones curved in a semicircle forming the cage, called the thorax, which holds the lungs and the heart. There are 12 pairs of them attached to the 12 upper vertebræ of the back; so that there are 12 vertebræ without ribs (*seven* in the neck above and *five* below), and 12 with them.

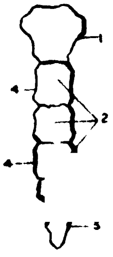
The seven upper pairs of ribs are also hinged in front on to the breast-bone, and are called true ribs; the other five pairs are not so hinged, and are called false ribs. These ribs are, however, united by cartilage in front to the lowest true rib, excepting the last two pairs, which are not fastened in front at all, and are sometimes called floating, or *free* ribs. Frogs have no ribs, but snakes have hundreds, on which they move; they use them instead of limbs; and the flying lizard flies with its ribs.

The Breast-bone. The breast-bone is called the *Sternum* [87], or sword, because it is just the shape of a short Roman sword or dagger in its sheath, with the handle above, and the point downwards, which you can feel in the middle of the chest. To the handle above, the arms are attached on each side by means of collar-bones.

The Collar-bone. The Clavicle [88], or collar-bone, is so called from Latin *clavis*, a key, and is fastened to the sternum at the inner end, and at the outer end to the shoulder-blade, with which it completes the socket for holding the arm. It is the shape of the letter "S," which is like an ancient key, and keeps the shoulders in their place. In animals, all of which have narrow, deep chests, these bones are very short indeed. The clavicle is easily broken by a fall upon the hands or arms. The two collar-bones in a fowl together form the "merry thought."

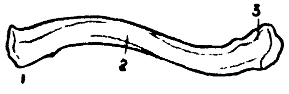


86. TRUE RIB
1. Head 2. Neck
3. Body 4. Junction with sternum



87. STERNUM
1. Handle or manubrium 2. Body
3. Ensiform process
4. Attachment of rib cartilage

The Shoulder-blade. The Scapula, or shoulder-blade (so-called from Latin *scapula*, a little boat), is a flat, triangular bone resting over the muscles of the back, on which it freely moves. It is united to the clavicle above, and forms the socket for the arm by means of a shallow cup at the outer angle, the point of the triangle being downwards



88. CLAVICLE (right side)
1. Inner or sternal end joins handle of breast-bone
2. Shaft 3. Outer or scapular end

Continued

THE BEGINNING OF ENGLISH PROSE

Characteristics of Prose. Periods of English Literature and Language. Ælfred and Chaucer. The Arthurian Legends.

Group 19
LITERATURE
11

Continued from page 1438

By J. A. HAMMERTON

THE student confronted for the first time with even an elementary work on English prose may well ask himself why he should study it. What *is* the use, for example, of an anthology of English prose? Is it compiled in order that the reader of it may be enabled to form some idea of the origin and development of the language at various periods of its history? Yes; and no. Philological considerations alone do not enter into such a work. There is as much fascination attached to the study of the growth of a language as there is to the pageant of history. But this is not all.

Why We should Study English Prose. "It is," as Professor Churton Collins says, "the privilege of Art and Letters to bring us into contact with the aristocrats of our race. It is the misfortune of philology that, in its lower walks at least, it necessitates familiarity with a class of writers who probably rank lowest in the scale of human intelligence." We study classic prose, in short, not only for the light it sheds upon the time in which it was written; not merely because of its intrinsic value as a means of knowledge; but also because of its style. And for yet another reason—which some would place above all the rest—because behind the style is a living man. Herein, for the true student of literature, as distinct from the "competition-wallah," is the secret charm of our standard literature, and especially of our standard prose. We know, sooner or later, that the noble eloquence, the rhythm, the colour, the tone, the deft management of the period, are all modelled by the great masters of English prose upon the works of the men who wrote in Greece and Rome when the world was young. But is that a cause for the withholding of our tribute of grateful admiration? Surely what is allowed to the plastic artist, the painter, the sculptor, the architect, cannot be denied the artist in words. And here let it be observed that the term "artist in words" is needlessly discredited by some superficial critics. It does not necessarily imply artificiality. Nothing that is artificial lives, except it be a sort of museum-life, in a glass case labelled "Specimen."

Character Revealed in Writing. Consequently, when we approach a work of living prose we may be certain that behind it is a great man, and something more, something of the character of the best of that man's contemporaries, of the spirit of the age in which he lived. It has been well said that genius is the same in all ages, and that writers in the rudest times, as well as those in a more polished and enlightened era, have reached those limits beyond which the faculties of the human mind seem unable to penetrate. Thus the elements of thought are only conditioned, not governed, by the outward circumstances of their expression.

The Peculiarity of Prose. Verse has been, certainly in English, far ahead of prose in the matter of settled law. Hence, as Sir Henry Craik has aptly indicated, you can imitate the rhythm of Spenser without seeming old-fashioned. No cadence in modern verse is more pure, more perfect, than that of Shakespeare's sonnets and lyrics; no later blank verse approaches the supreme art of Milton. But the prose of the masters and makers of it is personal in a double sense; it cannot be imitated. As one of those masters—Newman—has so well expressed it, "while the many use language as they find it, the man of genius uses it indeed, but subjects it withal to his own purposes, and moulds it according to his own peculiarities. The throng and succession of ideas, thoughts, feelings, imaginations, aspirations, which pass within him; the abstractions, the juxtapositions, the comparisons, the discriminations, the conceptions, which are so original in him; his views of external things, his judgments upon life, manners and history; the exercises of his wit, of his humour, of his depth, of his sagacity—all these innumerable and incessant creations, the very pulsation and throbbing of his intellect, does he image forth. To all does he give utterance in a corresponding language which is as multiform as this inward mental action itself and analogous to it, the faithful expression of his intense personality, attending on his own inward world of thought as its very shadow; so that we might as well say that one man's shadow is another's as that the style of a really gifted mind can belong to any but himself. It follows him about as a shadow. His thought and feeling are personal, and so his language is personal."

Language and Literature. In these pages we are not only conditioned, we are despotically governed, by the laws of space. We cannot attempt adequately to sample, we can only indicate (1) where the student must look for the leading examples of English prose, and (2) point out, as briefly as may be, the chief stages of our prose development. We shall not attempt a disquisition on Anglo-Saxon literature. That is a very special branch of learning, in which there are few experts. Nor is our aim philological. Not that we despise philology. That a devotion to philology is not incompatible with the sound appreciation of English literature as a whole, and that it may be the means of raising a conscientious student from a humble station in life to one of honour and influence is proved by the career of one of the most distinguished philologists of the present day, who, when a mill boy, taught himself to read, and thus set foot on the first rung of the ladder that leads to fame. In dealing with English prose, as in treating of English poetry, our object is to keep in view the needs of that large class of the community who should look to literature primarily as a means of education and the source of a pleasure which is not to be confounded with mere amusement.

Early Writers of Prose. The chief characteristic of Anglo-Saxon prose reflects what is a chief characteristic of the English character: practicality. The language was direct and simple. Another point to be borne in mind is that right up to and including the sixteenth century, our prose-writers, beginning with BÆDA (b. 673; d. 735), were in the main translators. Their works were for the most part educational, religious, and historical (as is the "Anglo-Saxon Chronicle") in character. ÆLFRED THE GREAT (b. 849; d. 901) was a translator himself and the cause of translation in others.

The English that Ælfred Wrote. Ælfred sought to give his people peace, and he laboured manfully to effect their intellectual improvement. He desired that at least every free-born youth who possessed the means should "abide at his book till he could well understand English writing." He sought to spread wide the learning which was then the monopoly of the clergy. Ballads and poems England already possessed. Prose she had none. He aimed at the rendering of all useful books "into the language which we all understand." This language has been described as one of the finest and purest forms of Teutonic speech. Into it Ælfred translated, or, rather paraphrased, in an epitomised form, the "universal history" of Orosius, a Spanish author of the fifth century; the "Historia Ecclesiastica" of the Northumbrian monk Bæda; the "Pastoral Rule" of Pope Gregory; and the "De consolatione philosophiæ" ("On the consolation afforded by philosophy") of Boethius, a Roman philosopher and martyr of the sixth century. Anglo-Saxon was distinct from modern English in the character of its lettering as well as in other ways, but some idea of "the English that Ælfred wrote" may be gleaned from the following example, which is given with modernised lettering, from the "De consolatione":

"Hit gelamp gio, thætte an hearpere wæs on thære theode the Thracia hatte. Thæs nama wæs Orpheus. He hæfde an swithe ænlic wif; sio wæs haten Eurydice."

Mr. Cardale thus renders this passage:

"It happened formerly that there was a harper in the country called Thrace. His name was Orpheus. He had an excellent wife called Eurydice."

The work from which these lines are quoted was also translated by Chaucer. Its theme is the mutability of all earthly things save virtue; it belongs to that rare order of immortal works that have been written in prison.

The English of Chaucer. To the development of Anglo-Saxon a period was placed by the Danish and Norman conquests. Some authorities object entirely to the term Anglo-Saxon as descriptive of the language and literature of England before the Norman conquest and for a century after that epochal event, preferring to classify the period as Oldest English, or Old English; but we may follow the conventional classification, which makes Early English succeed Anglo-Saxon and cover the years 1150-1350, as during the first of these two centuries the inflections were broken up, and in the second the language was extended by the introduction of numerous French words [see LITERATURE. page 324]. Middle English, of which Chaucer was the great literary artificer, flourished from 1350 to 1550, and since the latter date our language and literature are classed as Modern English [see page 328]. As was the case with the Anglo-Saxon and Early English writers, their successors of the fourteenth century concerned themselves chiefly with the work of translation. We have already learned that several of Chaucer's works are of this nature—two of the famous "Canterbury Tales": "The Tale of Melibeus," borrowed from the French of Albertano of Brescia, and "The Persones (Parson's) Tale," a sermon derived from Frère Lorens; the unfinished "Treatise on the Astrolabe"; and his "Boethius." Let us look at a few passages from the last named. It will serve to indicate how the language had grown since Ælfred's time.

"At the laste the lord and juge of sowles was moeved to misericordes [mercy] and cryde, 'we ben overcomen,' quod he; 'give we to Orpheus his wyf to bere him companye; he hath wel y-bought by his song and his ditee; but we wol putte a lawe in this, and covenaunt in the yifte: *that is to seyn*, that, til he be out of helle, yif he loke behinde him, that his wyf shal comen ayein unto us.'"

Resistance of English to Norman-French. Though the Norman conquest introduced Norman-French as the language of the court and the cultured classes, while Latin remained the language of the clergy and that in which many learned works were written, the native dialects merged into one another, and ultimately into the Midland tongue. That the French influence was by no means a negligible quantity is evident, if we examine the work of Chaucer alone; but the native English as successfully resisted the Norman-French invasion as our native drama in the sixteenth century rose superior to the dictates of the "University scribes," who sought to shackle it with the dead weight of classical tradition. Following upon the death of Chaucer, however, the French wars and the Wars of the Roses once more set back the clock of English literary activity, and there is but little of interest to chronicle, save the introduction of the printing press by WILLIAM CAXTON (b. 1422?; d. 1491), till we reach the age of the Tudors, whence may be dated the beginning of Modern English.

The Arthurian Legends. One example of the manner in which the English appropriated French literature is to be found in the anonymous translation of "The Voyage and Travels of Sir John Maundeville" of Jehan de Bourgogne, a work which is still read on account of its naïve descriptions of the marvellous. But especially interesting is it to ponder the influence of the romantic legends of the Norman poets known as the Trouvères. These deal with Alexander the Great, King Arthur and the Knights of the Round Table, Charlemagne, and the Crusaders. The origin of the Arthurian legends is Celtic—partly Welsh and partly Breton. "La Mort d'Arthure" of Sir THOMAS MALORY (fl. 1470) so delighted the heart of Sir Walter Scott that he described it as being indisputably the best prose romance of which the English language can boast. Many modern writers, Tennyson among them, are the eternal debtors of Malory, whose work, as printed with all the affection of a great and sympathetic craftsman by WILLIAM CAXTON, played no small part in the making of Elizabethan prose. For his black-letter folio of this work, of which only two copies are known to exist, though a number of reprints are obtainable, Caxton wrote a preface, in which he said, in language that indicates the rapidity of the change from Chaucer's:

Specimen of Caxton's Prose. "I have after the symple connyng that God hath sente to me, under the favour and correctyon of al noble lordes and gentylmen, enprysed to enprynte a book of the noble hystoryes of the said kynge Arthur, and of certeyn of his knyghtes, after a copye unto me delyvered, whyche copye syr Thomas Malorye dyd take oute of certeyn bookes of Frensshe and reduced it into Englysshe. And I, accordyng to my copye, have doon sette it in enprynte, to the entente that noblemen may see and lerne the noble acts of chyvalrye, the jentyl and vertuous dedes, that somme knyghtes used in tho dayes, by whyche they came to honour, and how they that were vycious were punysshed, and often put to shame and rebuke, humbly bysechying al noble lordes and ladyes, wyth al other estates, of what estate or degree they been of, that shal see and rede in this sayd book and werke, that they take the good and honest actes in their remembrance, and to folowe the same."

Malory's "La Mort d'Arthure." A favourite passage is Malory's account of the passing of Arthur. How English it is, apart from the spelling, may be seen from the following modernised extract:

"And when they were at the water-side, even fast by the bank hoved a little barge with many fair ladies in it, and among them all was a Queen, and they all had black hoods, and they all wept and shrieked when they saw King Arthur. 'Now put me into the barge,' said the king; and so they did softly. And there received him three Queens, and in one of their laps King Arthur laid his head, and then that Queen said, 'Ah, dear brother! why have ye tarried so long from me? Alas, this wound on your head hath caught overmuch cold.' . . . . Then Sir Bedivere cried, 'Ah, my lord Arthur what shall become of me now ye go from me, and leave me here alone among mine enemies?' 'Comfort thyself,' said the King, 'and do as well as thou mayst; for in me is no trust to trust in. For I will go into the Vale of Avillon, to heal me of my grievous wound. And if thou hear never more of me, pray for my soul.'"

Froissart. Malory's monumental work, following that of Chaucer and Gower, gave to English literature something of the glamour of chivalry and romance; and this beneficent influence was followed in its turn by the translation of Froissart's "Chronicles" by LORD BERNERS (or BOURCHIER) (b. 1467; d. 1533). Jean Froissart, like one of his own heroes, set out on his travels in quest of adventure. He visited England twice, in the reign of Edward III. and Richard II.; he was the guest of David Bruce in Scotland, he journeyed in Aquitaine with the Black Prince, and was in Italy, possibly with Chaucer and Petrarch. Ten years before his death he settled in Flanders. His "Chronicles," drawn from his travels and experiences, are among the most delightful things in European literature. Those who cannot read them in French, and are not in love with the spelling of Lord Berners' translation, should have recourse to the Globe edition, which gives a modernised version by Mr. G. C. Macaulay.

The Paston Letters. The student of fifteenth century England should not omit to pay some attention to the "Paston Letters" (1422-1509). These documents, which are about 1,000 in number and were not printed till the second half of the eighteenth century, were written during the reigns of Henry V., Edward IV., Richard III., and Henry VII., by members of an East Anglian family. They throw a flood of light on the social customs of fifteenth century England; and they serve to indicate that the civil strife which then divided families did not altogether crush out either the desire for, or the means of, learning.

The Author of "Utopia." Sir THOMAS MORE (b. 1480; d. 1535) was a man whose thoughts were far in advance of his time. His theories were essentially those of a humane man and a philosopher; his practice, as Chancellor of Henry VIII., was curiously at variance with his avowed sympathies. He was beheaded for refusing to acknowledge any other head of the Church than the Pope. His best known work, the "Utopia," a political satire, was written in Latin, and translated into English by Ralph Robynson thirty-five years later. It deals with the social defects of English life, and pictures an imaginary island where communism is the rule, education common to the sexes, and religious toleration general. The title is derived from two Greek words meaning "Nowhere." More also wrote a number of works in English, of which the most notable is his "Historie of Edward the Fifth and Richard the Third." This is the first history in the language with any pretension to a literary character.

Continued

TAKING OUT LETTERS PATENT

A Provisional Patent. Complete Letters Patent. Renewal Fees. The Patent Agent. British and Foreign Patent Practice

THE man who wishes to secure patent rights for his invention is usually well advised if, in the first instance, he seeks *provisional protection* only. Complete letters patent may follow, but the cost of the latter is greater, and the probationary period of provisional protection gives him time in which to develop details. He may make application through a patent agent—a course which is usually wise. To frame the specification requires a terseness and exactness of description, with some knowledge of the formalities of Patent Office procedure, which are usually gained only by experience. But if the inventor decide to plough his own furrow to the end there is nothing to prevent his doing so.

In such a case he should apply to the Patent Office, 25, Southampton Buildings, Chancery Lane, London, W.C., for the pamphlet "Instructions to Applicants for Patents," which he may have free of charge. He will receive valuable aid in the framing of his own specification from the publication "Patent Rules, 1903" (price 6d., or by post 7d.), and "Patent Rules, 1905" (price 1d., or by post 1½d.). These are also to be had at the Patent Office. They show duplicates of the various forms to be lodged in patent practice.

Provisional Protection. Provisional protection for an invention allows an inventor a period of six months in which to develop his invention before fixing its final detailed form and paying the higher fee for complete letters patent. The period may be extended to seven months upon payment of an extra fee of £2.

Application for a provisional patent requires Form A, which bears a 20s. stamp, and Form B in duplicate, which carries no stamp. All these forms, costing 20s., may be purchased at Room No. 6, Inland Revenue Office, Royal Courts of Justice, Strand, London, or, by giving a few days' notice, at any money-order office in the United Kingdom. Upon Form A the declaration and application must be made, and upon the two forms B the specification must be written.

Patent agents usually charge from £2 10s. to £4 for drawing up the provisional specification and making the application, the charge including the 20s. stamp. The latter figure is supposed to be the regulation fee, and is maintained by agents of the highest standing, but many others charge less.

Complete Letters Patent. Having taken out provisional letters patent, the inventor may exhibit his invention to whom he will, make it, and sell it if he can. He may not, however, designate his article *patent*, but may attach to it the words "provisionally patented," or "patent applied for." If, during the six months after the date of application for provisional protection, he find that his invention has no practical value, he will do nothing further with it; but if he should find that he has evolved something likely to be lucrative, he will take out complete letters patent. The complete application must be lodged upon Form C, which carries a £3 stamp, and which may be purchased at the sources already mentioned. The patent agent's fee for complete patent application, including stamp, is usually from £5 5s. upwards, according to the nature and length of the specification and drawings. This fee does not include the sealing fee of 20s. If no provisional patent has been taken out before the complete patent the charge is from £6 6s. up, as the official fee is, in such a case, £4. The best firms charge £10 10s. for the work, including stamp, and as the whole value of a patent depends upon the manner of framing the specification, lower terms often mean a loosely-drawn and worthless patent. Drawings are not demanded with a provisional application, but are essential in a complete specification if the invention be of a mechanical nature.

Examination and Sealing. The officials of the Patent Office examine the specification accompanying every application for complete letters patent, and all published specifications of a similar nature lodged in the British Patent Office during the period of 50 years immediately preceding, to ascertain if the invention has been anticipated. If the search should discover an absolute anticipation, or even only anticipation of a detail, which appears to qualify the originality of the invention which is the subject of the application, the comptroller may endorse the specification of the new application, mentioning the previous specifications. It is the object of every applicant for letters patent to have his application passed without such endorsement, and to this end the skilled patent agent may yield valuable assistance. A knowledge of the prior specification or specifications which might be recorded upon the new specification and thereby modify its value, may enable the patent agent to alter the specification, and thus obtain a clean certificate without sacrificing any vital feature of the new invention.

When intimation has been received that a patent specification has been passed, it must be sealed to obtain validity. Application for sealing must be made upon Form X, which carries a 20s. stamp.

The granting of a patent is no certificate of its validity, and the patentee should remember this.

COST AND DURATION OF COLONIAL AND FOREIGN PATENTS

For British values of Foreign Money Standards, see page 409

Countries marked thus * are members of the International Convention, under which applications for patents may be made within 12 months of the date of the earliest foreign application, and priority obtained as and from the date of such prior application.

BRITISH COLONIES AND POSSESSIONS

Country.	Provisional Specification.		Complete Specification.			Subsequent Official Fees, and Remarks.
	Duration.	Official Fee.	Period.	Official Fee.	Limit of Patent Life.	
Australia..	9 months	£1	7 years	£2	14 years	£5 on expiry of 7th year. Not patentable beyond 1 year after exhibition in Colony.
Bahamas..	None	None	7 years	£15 7s. 6d.	21 years	For 2nd and 3rd 7-year terms, £10 and £20 respectively. Any foreign specification must be lodged with application.
Barbados	9 months	£4 13s.	4 years	£5 13s.	14 years	Annual fees, 5th to 8th year, £10; 9th and 10th year, £15; 11th to 14th year, £14. No conditions of working.
Bermuda..	9 months	£1	14 years	£6 10s. to £11 10s.	—	None. Extension possible in 7-year periods as often as Governor may direct.
Borneo (British North)	None	None	14 years	50 dollars	14 years	None. Extension up to other 14 years at discretion of Governor.
British Guiana	9 months	20 dollars	7 years	30 dollars	14 years	100 dols. before end of 7th year. Fee for registration of assignment on licences, 10 dols.
British Honduras* ..	6 months	10 rls.	2 years	10 rls., plus 40 dols.	14 years	3rd year, 52dols.; 7th year, 103dols. Patent expires with expiry of any foreign patent.
Canada	None	None	6 years	20 dollars	18 years	20 dols. at end of 6th year. and at end of 12th year. Patent must be taken within 1 year of any foreign application.
Cape Colony	None	None	3 years	† £7 4s. 6d.	14 years	Before end of 3rd year £10, and 7th year £20. Patent lapses with expiry of any foreign patent.
Cent'l African Protect'rate		Similar to British Patent Regulations.				
Ceylon		Similar to Regulations applying to India.				All documents *re* patents by non-residents must be signed by agent under power of attorney.
Channel Islands.. ..	British patents extended to Channel Islands by registration in Guernsey and Jersey. Fee. £5 to £6 for each registration.					
East African Protectorate	—	—	4 years	40 rupees	14 years	Before end of 4th year, 100 rupees; before end of 8th year, 200 rupees. Extension beyond 14 years possible under certain conditions.
Falkland Islands .	British patents extended to Falkland Islands on payment of Government fee of £5.					
Fiji	None	None	14 years	£21 5s.	14 years	No renewal fees or working conditions.
Gambia	9 months	£4 13s.	4 years	£5 13s.	14 years	For 5th to 8th year, £10 per annum; 9th and 10th year, £15; 11th to 14th year, £20.
Gold Coast Colony ..		Conditions as for Gambia.				
Grenada (West Indies) ..	9 months	† £3	4 years	† £2	—	For 5th year £3, rising £1 per annum to £7 for 9th year. For 12th year, £12.
Hong Kong	Patents granted only for inventions already patented in Great Britain.					Total fees. 35 dols. Patent lapses on lapsing of British patent.
India	None	None	4 years	40 rupees	14 years	Annual tax for 5th to 9th year, 50 rupees; for 10th to 12th year, 100 rupees. Applications for foreign inventions must be made within 12 months of foreign patent applications.
Jamaica	None	None	14 years	£7 15s.	14 years	None. Patent lapses with first foreign patent to lapse.
Labuan		Similar to Regulations in Straits Settlement.				
Lagos		Similar to Regulations in Gambia.				
Leeward Islands ..	6 months	£2 10s.	3 years	Conditional	14 years	Before end of 3rd year, £10; before end of 7th year, £20. Patent lapses with first foreign patent to lapse.
Malta and Gozo ..	6 months	£1	4 years	£3	14 years	Before end of 4th year, £5, and annual fee increasing £1 each year. Publication before application renders patent void.
Mauritius..	None	None	14 years	† £12	14 years	None. Patents extended for other 14 years at discretion of Governor.
Natal	6 months	£1 1s.	3 years	£5 7s.	14 years	Before end of 3rd year, £5; before end of 7th year, £10. Patent lapses with lapse of any foreign patent.
Negri Sembilan		Regulations as in Pahang.				
Nigeria		Regulations similar to those in Gambia.				
Newfoundland	None.	None	14 years	Conditional	14 years	Patent lapses with lapse of any foreign patent. Samples of invention or model of machine usually required.
New Zealand*	9 months	10s.	4 years	£2 10s.	14 years	Before end of 4th year, £5; before end of 7th year, £10. Patents granted although published in N.Z. if applied for within 12 months of date of British patent.
Orange River Colony ..	None	None	3 years	£13 8s.	14 years	Before end of 3rd year, £5; before end of 7th year, £10. Patent lapses with lapse in any other country.
Pahang	6 months	5 dollars	7 years	50 dollars	14 years	At expiry of 7th year. 25 dols. Resident agent necessary.

† Plus advertising charges.

BRITISH COLONIES AND POSSESSIONS—Continued

Country.	Provisional Specification.		Complete Specification.			Subsequent Official Fees. and Remarks.
	Duration.	Official Fee.	Period.	Official Fee.	Limit of Patent Life.	
Perak	Regulations as in Pahang.					
Rhodesia	9 months	£1	2 years	† £3	14 years	£2 for 3rd year, rising 10s. a year.
St. Helena	—	—	—	£1 1s.	—	Patents granted only for inventions already patented in Great Britain and for term [of British patent
St. Lucia	9 months	£3	4 years	† £2	14 years	For 5th year £3, rising £1 per annum.
St. Vincent	Regulations as in St. Lucia.					
Selangor	Regulations as in Pahang.					
Seychelles Islands	6 months	46.50 rupees	4 years	56.50 rupees	14 years	Annual taxes for 5th to 7th year, 100 rupees: 8th and 9th year, 150 rupees; for 10th to 14th year, 200 rupees.
Sierra Leone	9 months	£1	4 years	£4	14 years	Renewal fees as in Great Britain.
Soudan	There are no Patent Regulations.					
Straits Settlements	None	None	14 years	50 dollars	14 years	None. Application granted for any British patent during its validity in Gt. Britain
Transvaal	9 months	£1	2 years	† £3	14 years	£2 for 3rd year, increasing 10s. per annum. Grounds of opposition numerous.
Trinidad and Tobago	9 months	£1	14 years	£10 10s.	14 years	
Zanzibar	None	None	4 years	40 rupees	14 years	Before end of 4th year, 100 rupees; before end of 8th year, 200 rupees. Application after 12 months of foreign application invalidates.
Zululand	Natal patents cover Zululand.					
FOREIGN COUNTRIES						
Argentine Republic	1 year	50 pesos	5 years 10 years 15 years	40 pesos fuertes 100 ,, ,, 175 ,, ,,	15 years	Half the fee may be paid on application, and remainder by annual payments. Pharmaceutical preparations not patentable. Limit for invention already patented elsewhere, 10 years. Working within 2 years of granting essential.
Austria (not including Hungary).	None	None	Application only	30 crowns	15 years	Annual tax, beginning 20 florins 1st year, increasing annually to 340 florins 15th year. Inventions contrary to State monopolies not patentable. Revocation possible unless property worked within 3 years.
Belgium*	None	None	1 year	10 francs	20 years	Second year, 20 francs, rising 10 francs per annum. Working necessary within 1 year.
Bolivia	—	—	—	—	15 years	Working within 1 year necessary. Cost depends on capital to be sunk in manufacture.
Brazil*	None	None	15 years	According to length of specification	15 years	20 dollars 1st year, rising 10 dollars each year. Fee for analysis of chemical patents, £4 to £5. Working necessary.
Bulgaria	There is no Patent Law.					
Chili	None	None	10 years	100 dollars	10 years	No renewal fees. Working necessary, within time fixed for each individual patent.
China	There is no Patent Law.					
Colombia	None	None	5-20 years	70 dols., plus taxes	20 years	5-20 dollars for each year of patent, payable before granting. Working necessary. Patent lapses with lapse of foreign patent.
Congo Free State	None	None	20 years	100 francs	20 years	No renewal fees. Working not essential.
Corea	There is no Patent Law.					
Costa Rica	—	—	—	—	20 years	Working necessary within 2 years.
Cuba	—	—	—	35 dollars	—	
Denmark*	None	None	1 year	35 crowns	15 years	2nd and 3rd years 25 crowns, annually increasing to 300 crowns for 15th year. Inventions for production of food not patentable.
Danish West Indies and Iceland.	Regulations similar to Danish. Inventions not patented in Denmark may be patented for 5 or 10 years.					
Dominican Republic	There is no Patent Law.					
Ecuador	Similar to Bolivia.					
Egypt	No Patent Law, but protection for inventions secured by registering them at several of the Mixed Courts.					
Finland	None	None	1 year	30 marks	15 years	Annual fee, beginning 20 marks for 2nd and 3rd year, and rising to 70 marks for 13th to 15th year. Working necessary within 3 years.
France*	None	None	1 year	100 francs	15 years	Annual fee of 100 francs. Pharmaceutical compounds not patentable. Patent lapses with lapsing of foreign patent. Working within 2 years necessary.
Algeria Madagascar Tunis	Colonies of France, and covered by French Letters Patent.					
Germany (including all German Colonies)*	2 months	20 marks	1 year	30 marks	15 years	For 2nd year 50 marks, increasing 50 marks annually. Working within 3 years necessary.

† Plus advertising charges.

FOREIGN COUNTRIES—Continued

Country.	Provisional Specification.		Complete Specification.			Subsequent Official Fees, and Remarks.
	Duration.	Official Fee.	Period.	Official Fee.	Limit of Patent Life.	
Guatemala	None	None	5—15 years	—	—	30 pesos annually. Working within 1 year necessary.
Hayti		There is no Patent Law.				
Holland		There is no Patent Law.				
Honduras	None	None	1 year	10-50 pesos	20 years	10-50 gold pesos annually.
Hungary	None	None	1 year	60 crowns	15 years	Annual tax 50 crowns 2nd year, rising to 500 crowns for 15th year. Working within 3 years necessary. Articles of food and chemical products not patentable.
Italy*	None	None	1 year	40 lire, plus 10 lire per year of period	15 years	Progressive annual tax, beginning 40 lire, to 140 lire. Working necessary. Applicants must state on application the total period for which patent is desired.
Japan*	None	None	1 year	10 yen	15 years	10 yen annually, increasing 5 yen every 3 years. No patents granted for articles of food, drink, or luxury. Working within 3 years necessary. Models of inventions must be lodged.
Liberia	None	None	20 years	50 dollars	20 years	No renewal fees. Working within 3 years necessary.
Luxembourg	None	None	1 year	10 francs	15 years	Second year, 20 francs, rising 10 francs annually. Articles of food and pharmaceutical compounds not patentable. Patent conditional upon grant of patent in Germany.
Mexico*	None	None	1 year	5 dollars	20 years	35 dollars at end of 1st year, but no further fees. Chemical products not patentable.
Montenegro		There is no Patent Law.				
Morocco		There is no Patent Law.				
Mysore		Conditions are the same as for India.				
Nicaragua	None	None	1 year	20-100 pesos	10 years	20-100 pesos annually. Working within 1 year nceessary.
Norway*	None	None	1 year	30 crowns	15 years	10 crowns for 2nd year, increasing 5 crowns annually. Working within 3 years necessary.
Panama	Regulations similar to those in Columbia. Tax is 20 dollars for each year of term asked for.					
Paraguay	Patents granted in Argentina, Bolivia, Peru, Uruguay, can be registered for Paraguay within 1 year.					
Persia		There is no Patent Law.				
Peru	None	None	10 years	100 dollars	10 years	No renewal fees. Working necessary, usually within 2 years.
Portugal (including Azores and Madeira)*	None	None	1 year	3 dollars	15 years	Fee of 3 dollars for each year of term applied for, payable with application. Chemical and pharmaceutical preparations not patentable. Working within 2 years necessary.
Portuguese Colonies	Portuguese patents may be extended to all Portuguese Colonies by paying 3 dollars for each year of term applied for.					
Russia	3 months	$1.60 roubles, plus .80 roubles for each 700 words in specification.	1 year	15 roubles	15 years	Annual tax, 2nd year, 20 roubles, rising to 400 roubles for 15th year. Working within 5 years essential,
Roumania		There is no Patent Law.				
Salvador	None	None	5 years	50-100 pesos	20 years	After 5 years, 50 pesos; 10 years, 75 pesos; 15 years, 100 pesos. Patent lapses with lapse of a foreign patent. Working not compulsory.
Servia		There is no Patent Law.				
Siam	British Patent Act covers Siam as far as resident British subjects are concerned.					
Soudan	There is no Patent Law, but registration in Egypt may be notified to Soudan authorities.					
Spain*	None	None	1 year	25 pesetas	20 years	For 2nd year 20 pesetas, rising 10 pesetas each year. Working within 3 years necessary.
Sweden*	None	None	1 year	20 kroners	15 years	Annual tax for 2nd to 5th year, 25 kroners; 6th to 10th year, 50 kroners; 11th to 15th year, 75 kroners. Working within 3 years necessary.
Switzerland*	None	None	1 year	40 francs	15 years	Annual tax, 30 francs for 2nd year, rising 10 francs per annum. Nothing impossible to be represented by model patentable.
Turkey	None	None	1 year	£T4	15 years	£T4 per annum from 2nd year. Working within 2 years essential.
United States*	None	None	17 years	35 dollars	17 years	No renewal fees. No conditions of working.
Uruguay	None	None	1 year	40 dollars	9 years	25 dollars per annum. Pharmaceutical preparations not patentable.
Venezuela	None	None	5 years 10 years 15 years	400 bolivars 800 „ 1,200 „	15 years	No renewal fees. Working essential. Pharmaceutical preparations not patentable.

Renewal Fees. The period to which a complete patent extends upon the application fee is four years, before the expiry of which a fee of £5 must be paid if it be the intention to maintain patent rights. The fee for the sixth year is £6, payable before the end of the fifth year, and the tax rises annually by 20s. increments, until the limit of 14 years is reached Renewal fees are paid under cover of Form J. which may be purchased in the same manner as the other forms already mentioned.

Renewal fees need not be paid through a patent agent, as the extra charge above the official fee is merely money thrown away. The patentee must, however, not forget the dates when the renewal fees fall due, else his patent may lapse through his carelessness. Should the date for paying any renewal fee pass, the patentee may regain his patent rights by paying an extra £1 if within one month, £3 if within two months, or £5 if within three months.

The Patent Agent. The choice of a patent agent, if one be employed, demands care. The Fellows of the Chartered Institute of Patent Agents, of Staple Inn Buildings, London, W.C., may be entrusted with the work in entire confidence. A registered patent agent must either have been in practice before 1888 or have passed a professional examination held by the Institute, the chief object of which is "to maintain a high standard of rectitude and professional conduct" Any agent on the register (which is kept by the Institute) who may be found guilty of malpractice is struck off the roll by the Board of Trade at the instigation of the Institute.

All *patent experts* are not *patent agents* It is illegal to assume the latter title unless the individual be registered. But anyone may without restriction call himself a *patent expert*, and may even call his office a *patent agency* or *patent office*. The inventor seeking to enter the official Patent Office—and it would be well that the law should be made to limit the use of this designation to the official department—may easily find himself in the office of a private individual or firm, and care must be exercised if he would avoid this misadventure.

Especially when foreign patents are being applied for, a man of the highest professional standing should be engaged. A low quotation for the application of a foreign patent should never cause the inventor to depart from this rule It is not uncommon for unscrupulous "patent agency" houses to take fees for applying for foreign patents, and to make no application. Under such circumstances it is easy to give a low quotation for the work. The inventor should always insist upon having the official receipts for the payment of foreign patent fees, and should not be satisfied merely with an acknowledgment of the specification papers, as in some foreign patent offices specifications may be lodged without accompanying fees. Until the fee is paid, no patent is, of course, granted, but the practice of giving acknowledgment of documents unaccompanied by fees makes it easy for swindlers to impose upon innocent inventors.

Foreign Patents. It is practically impossible for the individual inventor to apply for a foreign patent without engaging the services of a properly qualified patent agent. Thus, time and space would be wasted by a consideration of the detailed procedure in applying for foreign or colonial patents. But we give in tabular form some information regarding the duration and cost of all foreign and colonial letters patent. The figures given in the large table do not include agent's fees, drawings, cost of drawing up, or of translating the specification. The total cost of official fees and patent agents' services complete for any foreign patent varies considerably. Average inclusive minimum charges by London patent agents for a few of the chief colonies and countries are as follows.

		£	s			£	s
Australia	7 years	22	0	Germany	1 year	9	0
Canada	6 ..	12	0	Italy	1 ..	10	0
Cape Colony	3 ..	22	10	Japan	1 ..	25	0
India	4 ..	13	0	Norway	1 ..	12	10
Natal	3 ..	16	10	Portugal	15 ..	30	0
New Zealand	4 ..	11	10	Russia	1 ..	20	0
Transvaal	3 ..	21	10	Spain	1 ..	14	10
Belgium	1 ..	4	0	Sweden	1 ..	15	0
Denmark	1 ..	13	10	Switzerland	1 ..	10	10
France	1 ..	7	10	United States	17 ..	16	0

These fees include Government filing fees, specification and translation up to 1,000 words, but not drawings, which are invariably charged extra, according to their nature.

Marketing an Invention. There are several ways in which a patentee may exploit his invention. He may (1) manufacture it and sell the article to the trade or the public; (2) sell his patent outright; (3) grant an exclusive licence or several licences for its manufacture either for an annual slump money payment or upon a "royalty" basis—that is, receiving so much for each article made and sold. The first method is the more common with ordinary inventions devised by men in a position to manufacture and market the specific article invented; the third is the more usual when the inventor is not in a position to follow his creation through all its commercial stages, and the second, if he can arrange it, pays the inventor when his invention is a bad one, and the manufacturer when it is good. The most equitable arrangement between inventor and manufacturer is that the latter should undertake to make and sell the article for a certain number of years, paying a reasonable minimum annual sum for the privilege, and a further small royalty upon any number above a certain agreed quantity. The minimum annual payment is some guarantee that the manufacturer will take up the article seriously, and the royalty upon the excess secures consideration for the inventor if the article prove exceedingly valuable.

Limited companies are often formed solely to exploit a patented invention. An invention must be of importance and value to ensure success upon such a scale of working. The procedure of company formation is considered in another part of the SELF-EDUCATOR.

Patents and Inventions concluded

LATIN—ENGLISH—FRENCH—GERMAN

Latin and English by G. K. Hibbert, M.A.; French by Louis A. Barbe, B.A.; German by P. G. Konody and Dr. Osten

Group 18
LANGUAGES
11

Continued from page 1480

LATIN

Continued from page 1471

By Gerald K. Hibbert, M.A.

SECTION I.

Miscellaneous Idioms

English.	*Latin.*
Calpurnia married Cæsar.	Calpurnia Cæsari nupsit (lit., *veiled herself for Cæsar*).
Cæsar married Calpurnia.	Cæsar Calpurniam in matrimonium duxit.
He is the best scholar in the school.	Discipulorum, si quis alius, ille optime discit.
It does not fall to the lot of everybody to visit Naples.	Non cuilibet contingit Neapolim videre.
There are some who think you are mad.	Sunt qui putent te insanire.
I prefer a thousand deaths.	Malo sexcenties mori (the Latins always said *six hundred times* in such sentences).
I fear you are wrong.	Timeo ne erres.
I fear you are not wrong.	Timeo ut erres.
I will do it if I can.	Hoc si *potero* (*fut.*) faciam.
He pities no one.	Nullius miseretur (not *neminis*: gen. and abl. of *nemo* not used. " With *nemo* let me never see *Neminis* and *nemine*.")
I am sorry to say this.	Invitus hoc dico.
He perished in his youth.	Juvenis mortuus est.
I have asked him to come to see me as quickly as possible.	Rogavi eum ut quam celerrime veniat me visum (*supine*).
I cannot write for weeping.	Præ lacrimis scribere non possum.
One uses one tent, another another.	Alius alio tabernaculo utitur.
All the best citizens are present.	Optimus quisque civis adest.
It is all over with me.	Actum est de me.
You ought to have done it before.	Antea te hoc facere oportuit (*note the pres. infinitive*).
On the march.	Ex itinere.
On horseback.	Ex equo.
He departed without asking what I had done.	Discessit, neque quid fecissem rogavit (*or*, Ita discessit ut non rogaret, etc.). But not *sine* with gerund.
With your usual kindness.	Pro tua clementia.
In front was the sea, in our rear the enemy.	A fronte mare, hostes a tergo imminebant. (Note the "back to back" construction, called Chiasmus, *mare* and *hostes* being the two means, *a fronte* and *a tergo* the extremes).
He came sooner than he was expected.	Opinione celerius venit.
The House divided on the motion.	Pedibus in sententiam iverunt.
Once every four years.	Quarto quoque anno.
I am on the point of going.	In eo sum ut proficiscar.
In the open air.	Sub divo.
The sisters loved one another.	Sorores altera alteram amaverunt.
I was within an inch of death.	Minimum abfuit quin morerer.
Mind you come.	Cura (*or* Fac) ut venias, *or simply* Cura venias. (*Cura* is imperative of *curo, curare.*)
He is not a fit person for you to converse with.	Non est aptus quocum colloquaris.
I cannot walk even a mile, not to mention seven.	Ne mille passus quidem ambulare possum, nedum septem (millia passuum).
At one time he is wise, at another a perfect fool.	Modo sapiens, modo stultissimus est.
Some laws were passed, others remained posted up.	Leges aliæ latæ sunt, aliæ promulgatæ fuerunt.
What is the meaning of the word pleasure?	Quid vult vox voluptatis?
I asked him what time it was, but he made me no reply.	Mihi interroganti quota hora esset, nihil respondit.
I am writing this letter on the 1st of April.	Has literas (*or* hanc epistolam) Kalendis Aprilibus scribebam. (Epistolary imperfect, because to the reader the writing is *past*.)
It would be tedious.	Longum est.
It would have been better.	Melius fuit.

English.	*Latin.*
All the world knows that you are not convinced.	Nemo est quin sciat tibi non persuasum esse.
Instead of thanking me, he abused me.	Quum gratias mihi agere deberet, mihi maledixit.
"This, then, is the reason why pay has been granted to the soldiers: nor has it escaped our notice that this gift will be daubed with the poison of our enemies. The liberty of the people has been sold: our soldiery is removed for ever and banished from the city and from the republic: no longer do they give way even for winter or the season of the year and visit their homes and possessions. What do you think is the reason for this prolonged service?"	*In Oratio Obliqua.* Hoc illud esse quod æra militibus sint constituta; nec se fefellisse, id donum inimicorum veneno illitum fore. Venisse libertatem plebis: remotam in perpetuum et ablegatam ab urbe et ab republica juventutem jam ne hiemi quidem aut tempori anni cedere ac domos ac res invisere suas. Quam putarent continuatæ militiæ causam esse? (Livy.)
The top of the mountain.	Summus mons.
From day to day.	Diem de die.
To be brief.	Quid plura [dicam]?
As far as I know.	Quod sciam.
No letter from you.	Nulla tua epistola.
Every fifth year.	Quinto quoque anno.
To make many promises.	Multa polliceri.

SECTION II.

Definitions of Grammatical Terms

Asyndeton. The annexing of words without a conjunction—*e.g.*, *di, homines* (gods and men).

Aposiopesis. A sudden stopping on the part of the speaker, as though unwilling or unable to proceed—*e.g.*, Æneid I., 135:

"*Quos ego—sed motos præstat componere fluctus.*"

Hendiadys. The presentation of one and the same notion in two expressions—*e.g.*, "with might and main." *Chlamydem sinūsque* (the folds of the cloak: literally, the cloak and the folds).

Enclitic. A word or particle which always follows another word, so united to it as to seem a part of it—*e.g.*, -que, -ve.

Patronymic. A title expressing descent from a father or ancestor—*e.g.*, *Alcides* = son of Alceus; *Anchisiades* = son of Anchises.

Syncope. The shortening of a word by casting out an inner vowel; as, *patri* (*pateri*).

Synesis. A construction in harmony with the sense rather than with strict syntax—*e.g.*, *subeunt juventus auxilio tardi* = the young men come up slowly to the rescue. Here *subit* and *tarda* would have been strictly needed.

Crasis. The contraction of two vowels into one long vowel or into a diphthong.

Zeugma. The using of one verb in two different senses—*e.g.*, Æn. I., 264: *mores et mœnia ponet.*

Oxymoron. An apparent contradiction in terms—*e.g.*, *splendide mendax*: *insepultam sepulturam* (a mockery of burial).

Periphrastic Conjugation. The participles in *urus, dus* may be conjugated with all the tenses of *sum*—*e.g.*, to form fut. subj. of *amo*, "*amaturus sim.*"

Litotes. Understatement, saying less than one means—*e.g.*, "a citizen of no mean city." *non innoxia verba* (deadly words).

Hysteron-Proteron. The idea, logically second, being put first—*e.g.*, *moriamur, et in media arma ruamus.*

Chiasmus. Contrast obtained by reverse order—*e.g.*, *urbi Cæsarem, Brutum Galliæ (dederunt)*

Anaphora. Repetition of the verb to avoid the use of a conjunction—*e.g.*, *Venit et upilio; tardi venere subulci* (Virgil, Eclogues X., 19).

PASSAGE TO BE RENDERED INTO LATIN.

A CHARACTER SKETCH.

He belonged to those thin and pale men, as Cæsar names them, who sleep not in the night and who think too much; before whom the most fearless of all hearts has shaken. The quiet peacefulness of a face, always the same, hid a busy, fiery soul, which stirred not even the veil behind which it worked, and was equally inaccessible to cunning or love; and a manifold, formidable, never-tiring mind, sufficiently soft and yielding momentarily to melt into every form, but sufficiently proved to lose itself in none, and strong enough to bear every change of fortune. None was a greater master than he in seeing through mankind and in winning on hearts; not that he let his lips, after the manner of the court, confess a bondage to which the proud heart gave the lie; but because he was neither covetous nor extravagant in the marks of his favour and esteem, and by a prudent economy in those means through which one binds men, he multiplied his real store of them. Did his mind bear slowly, so were its fruits perfect; did his resolve ripen late, so was it firmly and unshakably fulfilled. The plan to which he once had paid homage as the first, no resistance would tire, no chances destroy; for they had all stood before his soul, before they really took place. As much as his mind was raised above terror and joy, so much was it subjected to fear; but his fear was there earlier than the danger, and in the tumult he was tranquil because he had trembled when at rest.

LATIN VERSION OF THE ABOVE PASSAGE.

Erat profecto e pallidis illis macilentisque viris quos dicit Cæsar [*or*, ut Cæsarianum illud usurpem] qui insomnia et nimia cogitatione exerciti terrorem aliquando vel fortissimis incusserunt. Vultui tranquillo et immobili suberat acer fervidusque animus, qui ne involucrum quidem sibi operanti quasi prætentum commovebat, contra fraudem et studia pariter obstinatus: suberat ingenium multiplex, formidulosum, indefessum, ita facile ut nullam non ex tempore formam indueret, ita duratum

ut nunquam a sua ipsius natura decederet, ita validum ut omnes fortunæ vicissitudines impune sustineret. Hominum indoles, ut nemo alius, perspiciebat, conciliabat gratiam: quem tamen ne putes, urbanorum more, obsequium, quod infitiaretur contemptor animus, ore professum esse, sed potius officiosæ benevolentiæ neque parcum neque prodigum, opes, quibus devinciuntur homines, caute dispensando auxisse. Mens ejus, si tardiores, perfectos certe edebat fructus; consilia ut serius provenissent, constanter tamen et sine vacillatione peragebantur. Propositum, cui semel primas detulisset, nulla vis oppugnantium frangere, nullæ vices labefactare poterant, quippe quas omnes animo jamdudum præcepisset Quantum super terrores et gaudia elata erat mens ejus, tantum timori erat subjecta: præveniebat vero timor ille periculum, adeo ut qui in tranquillo trepidavisset, in trepidatione ceterorum maneret tranquillus.—(J. Conington.)

Section III. TRANSLATION.

Passage from Virgil's Eclogues, or Pastoral Poems.

"THE GOLDEN AGE."

[*Virgil expresses the general hopes of a new era of peace and prosperity in language suggestive of the return of a bygone age of gold, connecting this age with the birth of a boy expected in this year,* B.C. 40.]

At tibi prima, puer, nullo munuscula cultu
Errantes hederas passim cum baccare tellus
Mixtaque ridenti colocasia fundet acantho.
Ipsæ lacte domum referent distenta capellæ
Ubera, nec magnos metuent armenta leones.
Ipsa tibi blandos fundent cunabula flores
Occidet et serpens, et fallax herba veneni
Occidet; Assyrium vulgo nascetur amomum.
At simul heroum laudes et facta parentis
Jam legere et quæ sit poteris cognoscere virtus,
Molli paulatim flavescet campus arista,
Incultisque rubens pendebit sentibus uva,
Et duræ quercus sudabunt roscida mella
Pauca tamen suberunt priscæ vestigia fraudis,
Quæ tentare Thetim ratibus, quæ cingere muris
Oppida, quæ jubeant telluri infindere sulcos.
Alter erit tum Tiphys, et altera quæ vehat Argo
Delectos heroas; erunt etiam altera bella,
Atque iterum ad Trojam magnus mittetur Achilles.
Hinc, ubi jam firmata virum te fecerit ætas,
Cedet et ipse mari vector, nec nautica pinus
Mutabit merces: omnis feret omnia tellus.
Non rastros patietur humus, non vinea falcem;
Robustus quoque jam tauris juga solvet arator;
Nec varios discet mentiri lana colores,
Ipse sed in pratis aries jam suave rubenti
Murice, jam croceo mutabit vellera luto;
Sponte sua sandyx pascentes vestiet agnos.
'Talia sæcla,' suis dixerunt, 'currite' fusis
Concordes stabili fatorum numine Parcæ.

Translation of the above Passage.

On thee, child, the earth shall begin to lavish without aught of tillage her simple gifts, straggling ivy twined with foxglove, and colocasia (the Egyptian bean) with smiling bear's-foot Of their own accord the she goats shall bring home their udders swollen with milk, and the herds shall not dread the mighty lions. Thy very cradle shall pour forth flowers to caress thee The serpent, too, shall perish; perish likewise the treacherous poison-plant. Eastern spice shall spring up everywhere. But so soon as thou shalt be able to learn the exploits of heroes and the deeds of thy father and what their manly virtue is, gradually the plain shall turn yellow with waving corn; on wild brambles shall hang the ruddy grape, and sturdy oaks exude the dew-born honey Yet shall there lurk a few traces of early guile, to bid men tempt the sea with barks, gird cities with walls, and cleave the earth with furrows Then shall be a second Tiphys (helmsman of the Argo) and a second Argo to carry the chosen heroes; there shall be the old wars repeated and a great Achilles sent again to Troy. Next, when thy full grown strength has made thee a man, even the merchant shall quit the sea, and the pine built ship shall not exchange its wares: every land shall bring forth everything. The ground shall not endure the hoe, nor the vineyard the pruning hook: the stout ploughman, too, shall now loose his oxen from the yoke. Wool shall not learn to assume divers colours, but by Nature's gift (ipse) the ram in the meadows shall exchange his fleece for sweetly-blushing purple and for saffron dye. Of its own accord scarlet shall clothe the browsing lambs "Ages like these, run on!" said the Parcæ to their spindles, uttering in concert the fixed will of Fate.

Those desirous of pursuing Latin Prose further are recommended to use Abbott's "Latin Prose through English Idiom"; "Arnold's Latin Prose Composition," by Bradley; and "Translations," by Messrs. Jebb, Jackson, and Currey (George Bell and Sons), to all of which books, with the addition of Roby's Latin Grammar and the Public School Latin Primer, the writer wishes to acknowledge his indebtedness.

Note. On page 1183, section 8*a*, the word *essent* should be *sint*.

Continued

ENGLISH

Continued from page 1475

By Gerald K. Hibbert, M.A.

PARSING

We have now gone through all the parts of speech in detail, and have been "parsing" words, perhaps unconsciously, throughout the process. For to "parse" a word is simply to say to what part of speech it belongs, and how it is related to other words in the same sentence.

Parsing Scheme. 1. Noun. Give (1) general class—*i.e.*, proper, common, abstract, collective ; (2) gender ; (3) number ; (4) case ; (5) reason for the case.

2. Adjective. Give (1) class, whether of quality, quantity, or relation ; (2) degree, whether positive, comparative or superlative ; (3) its qualification of the substantive. If the adjective in question is pronominal—*i.e.*, also used as a pronoun—state this in parsing it.

3. Pronoun. Give (1) class, (2) gender (if possible), (3) number, (4) case, with reasons for the number and the case.

4. Verb. If a finite verb, give (1) voice, (2) mood, (3) tense, (4) number, (5) person, and the subject with which it agrees.

If an infinitive or gerund, give (1) voice, (2) tense, (3) case, with a reason for the case.

If a participle, give (1) voice, (2) tense, (3) number, (4) case, and the substantive with which it agrees.

In *all* moods, say whether the verb is transitive or intransitive, whether of weak conjugation or of strong, and give the principal parts of the verb—*i.e.*, present indicative, past indicative, and past participle.

5. Adverb. Give (1) class, (2) degree, (3) what it qualifies.

6. Preposition. State what it governs.

7. Conjunction. Give its class, and say what sentences or words it connects.

Example of Parsing.

"But then the mind much sufferance doth o'erskip,
When grief hath mates, and bearing fellowship "
("King Lear.")

But. Co-ordinative conjunction, connecting this sentence with what has gone before.

Then. Adverb of time, modifying "doth o'erskip."

The. Demonstrative adjective, pointing out "mind" (sometimes called definite article).

Mind. Abstract noun, neuter, singular, nominative because subject of "doth o'erskip."

Much. Adjective of quantity, positive, qualifying with "sufferance."

Sufferance. Abstract noun, neuter, singular, objective, governed by "doth o'erskip."

Doth o'erskip. Verb, transitive, weak conjugation, active, indicative, present, singular third person, agreeing with its subject "mind," from *o'erskip, o'erskipped, o'erskipped.*

When. Relative adverb (or conjunctive adverb) of time, modifying "hath."

Grief. Abstract noun, neuter, singular, nominative, because subject to "hath."

Hath. Verb, notional (not auxiliary here), transitive, weak, active, indicative, present, singular, third person, agreeing with its subject "grief," from *have, had, had.*

Mates. Common noun, common gender, plural, objective after "hath."

And. Co-ordinative conjunction, joining the two sentences "Grief hath mates," and "Bearing (hath) fellowship."

Bearing. Abstract noun, neuter, singular, nominative, subject to "hath" understood

Fellowship. Abstract noun, neuter, singular, objective after "hath" understood.

N B. Parse compound tenses of a verb—*e.g.*, *have been, shall be leaving,* all as one word. We could, of course, split them up and parse the words separately, but there is no need to do this.

ANALYSIS

Complex Sentences. The method of analysing simple sentences was given on page 760. When we analyse a complex sentence, we first pick out the principal clause, and insert the subordinate clauses as parts of the principal clause. Then we analyse the different subordinate clauses, omitting the connecting words

For example :

"There is some soul of goodness in things evil
Would men observingly distil it out."

The principal clause is "There is some soul of goodness in things evil," and the subordinate clause "(If) men would observingly distil it out."

Subject	Limitation of Subject.	Predicate.	Limitation of Predicate.	Object.
soul	(*a*) some (*b*) of goodness	is	(*a*) in things evil (*b*) would men observingly distil it out	——
men	——	would distil	(*a*) observingly (*b*) out	it

Again :

"If you catch him when you reach home, give him the message which I will give you now."

The principal clause is "give him the message" ; the other three clauses are subordinate.

1. Principal Clause

Subject.	Limitation of Subject.	Predicate.	Limitation of Predicate.	Object.	Limitation of Object.
(you)	——	give	(*a*) him (*b*) if you catch him when you reach home	message	(*a*) the (*b*) which I will give you now

2. Subordinate Clauses

(*a*) If you catch him when you reach home.					
you	—	catch	when you reach home	him	—
(*b*) When you reach home.					
you	—	reach	home	—	—
(*c*) Which I will give you now					
I	—	will give	(*a*) You (*b*) now	which	—

Classification of Clauses. As has been mentioned previously, there are three kinds of clauses:

1. Clauses that play the part of a substantive in relation to some part of the sentence—*i.e.*, *Substantival* clauses.

2. Clauses that play the part of an adjective in relation to some part of the sentence—*i.e.*, *Adjectival* clauses.

3. Clauses that play the part of an adverb in relation to some part of the sentence—*i.e.*, *Adverbial* clauses.

Examples. SUBSTANTIVAL: "We know *that you are wrong*" (this clause is the object of "know"); "*When the election will come* is uncertain" (this clause is the subject of "is").

ADJECTIVAL: "Give me the portion of goods *that falleth to me*" (qualifies "portion"); "That is the spot *where Nelson fell*" (qualifies "spot"). Similarly with all clauses thus introduced by a relative pronoun (expressed or understood) or a relative adverb. Care must be taken, however, to distinguish such clauses from clauses involving an indirect question—as: "Tell me *where Nelson fell*," "I asked *where I was*," "I know *why you have come*." In these sentences the dependent clauses are substantival, representing substantives; there is no antecedent to which they can relate.

ADVERBIAL: "He died *while I was standing by*" (qualifying "died"); "We love Him *because He first loved us*" (modifying "love"); "Do *as I tell you*" (modifying "do")

EXERCISE

Classify the subordinate clauses in the following extract from Scott's "Lay of the Last Minstrel," and parse the words in italics.

> "But when he reached the hall of state,
> *Where* she and all her ladies *sate*,
> *Perchance* he wished the boon *denied*;
> *For*, when to tune his *harp* he tried,
> His *trembling* hand had lost the ease
> *Which* marks security to please."

NOTE. On page 1185, line 29 in the second column, *in* should be *than*

Continued

FRENCH

Continued from page 1477

By Louis A. Barbé, B.A.

NUMERALS

1. Cardinal Numbers

1 The cardinal numbers (*adjectifs numéraux cardinaux*) are:

0,	zéro
1,	un
2,	deux
3,	trois
4,	quatre
5,	cinq
6,	six
7,	sept
8,	huit
9,	neuf
10,	dix
11,	onze
12,	douze
13,	treize
14,	quatorze
15,	quinze
16,	seize
17,	dix-sept
18,	dix-huit
19,	dix-neuf
20,	vingt
21,	vingt et un
22,	vingt-deux
23,	vingt-trois, etc.
30,	trente
31,	trente et un
32,	trente-deux
33,	trente-trois, etc.
40,	quarante
41,	quarante et un
42,	quarante-deux
43,	quarante-trois, etc.
50,	cinquante
51,	cinquante et un
52,	cinquante-deux
53,	cinquante-trois, etc.
60,	soixante
61,	soixante et un
62,	soixante-deux
63,	soixante-trois
64,	soixante-quatre
65,	soixante-cinq
66,	soixante-six
67,	soixante-sept
68,	soixante-huit
69,	soixante-neuf
70,	soixante-dix
71,	soixante et onze
72,	soixante-douze
73,	soixante-treize
74,	soixante-quatorze
75,	soixante-quinze
76,	soixante-seize
77,	soixante-dix-sept
78,	soixante-dix-huit
79,	soixante-dix-neuf
80,	quatre-vingts
81,	quatre-vingt-un
82,	quatre-vingt-deux
83,	quatre-vingt-trois
84,	quatre-vingt-quatre
85,	quatre-vingt-cinq
86,	quatre-vingt-six
87,	quatre-vingt-sept
88,	quatre-vingt-huit
89,	quatre-vingt-neuf
90,	quatre-vingt-dix
91,	quatre-vingt-onze
92,	quatre-vingt-douze
93,	quatre-vingt-treize
94,	quatre-vingt-quatorze
95,	quatre-vingt-quinze
96,	quatre-vingt-seize
97,	quatre-vingt-dix-sept
98,	quatre-vingt-dix-huit
99,	quatre-vingt-dix-neuf
100,	cent
101,	cent un
200,	deux cents
201,	deux cent un
1,000,	mille
1,000,000,	un million
1,000,000,000,	un milliard

2. The old forms for 70, 80, 90, *septante*, *octante*, *nonante*, are seldom seen in print, but may occasionally be heard. Their derivatives:

septuagénaire, octogénaire, nonagénaire are still in common use to designate persons 70, 80, or 90 years of age. For *soixante* the corresponding form is *sexagénaire*.

3. The conjunction *et* is used in the first number of every new decade from *vingt et un*, 21, to *soixante et onze*, 71. It is not used after *cent*, hundred; *cent cinq*, 105; *cent vingt*, 120; but by some it is again used after *mille*, 1,000: *les Mille et une Nuits*, the Thousand and One Nights.

4. No preposition must be placed between the cardinal number and a noun; but *de* is required after *million* and *milliard*, which are really nouns: *Deux millions de francs*. For this reason they have *un* before them when used in the singular, and they take *s* when in the plural. *Cent* and *mille* are occasionally used as nouns of measure, and then follow the same rule: *deux cents de poires, un mille de fagots*.

5. *Vingt*, twenty, and *cent*, hundred, take *s* when they are multiplied by a number, but not followed by one. As regards *vingt*, *s* occurs in the one number 80 only: *quatre-vingts, deux cents*; but *quatre-vingt-un, deux cent deux*.

6. When *vingt* and *cent* are used as ordinal numbers, or when they occur in dates, they do not take *s*: *l'an quatre-vingt*, the year 80; *l'an huit cent*, the year 800; *page quatre-vingt*, page 80; *page deux cent*, page 200.

7. When the word thousand occurs in a date of the Christian era, and is followed by another number, it is written *mil*: *mil neuf cent cinq*, 1905; but *l'an mille*, the year 1000

8 The cardinal numbers, and not the ordinal as in English, are used to indicate the order of succession of sovereigns and the days of the month, after the first: *Charles deux, Henri quatre, le trente juillet, le quinze novembre*. In indicating the order of sovereigns, no article is used before the numeral. In indicating the day of the month, an article is used before the numeral, but no preposition after it.

9. In dating letters, figures are commonly used. The use of the article before them is optional. Sometimes *ce* (this) is used Thus:

London, May 28th: *Londres, 28 mai. Londres, le 28 mai. Londres, ce 28 mai.*

10. In indicating the hour of the day, "twelve" is not used. *Midi* (midday), and *minuit* (midnight) are used instead.

11 In multiplying and adding, the verb *faire* (to make) is used instead of "to be."

Deux fois deux font quatre.
Twice (two times) two are four.
Neuf et sept font seize.
Nine and seven are sixteen.

II. Ordinal Numbers

1. The ordinal numbers (*adjectifs numéraux ordinaux*) are formed from the cardinals by adding *ième*: *troisième*, third; *huitième*, eighth.

2. If the cardinal number ends in *e*, that *e* is omitted. The *s* of *quatre-vingts* is also dropped, *quatrième*, 4th; *onzième*, 11th; *quatre-vingtième*, 80th.

3. "First" is *premier*; but the regular form, *unième* is used for the first of every decade from 21st to 61st, and also after *cent* and *mille*. *Vingt et unième, trente et unième, cent et unième, mille et unième*.

4. "Second" has the two forms *second*, (fem. *seconde*) and *deuxième*. *Second* is used of the *second* of two, *deuxième* of the second in a longer series.

5. In "fifth" the *u* which is the only vowel that can follow *q* is inserted: *cinquième*.

6. In "ninth," the final *f* of *neuf* is changed into *v*: *neuvième*.

7. *Premier* is used for "first" in indicating the order of sovereigns and the day of the month: *Charles premier, le premier janvier*; but *le vingt et un juillet, le trente et un août*.

8. A special ordinal, *le quantième* (literally, the "how-*manieth*") is used for "the day of the month"; thus: *Quel est le quantième?* What day of the month is it?

III. Fractions

1. The ordinal numbers are used as fractions, except in the case of $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{3}$, $\frac{1}{4}$, $\frac{3}{4}$. Thus: *un sixième*, $\frac{1}{6}$; *deux cinquièmes*, $\frac{2}{5}$.

2. "Half" is *demi*. It is masculine as an arithmetical value. When preceding a noun it is joined to it by a hyphen, and is invariable: *une demi-bouteille*, half-a-bottle When it follows the noun it agrees with it in gender: *une bouteille et demie*, a bottle and a half; *trois heures et demie*, three hours and a half As a noun, "half" is *moitié*: *la moitié de la nuit*

3. The "thirds" are *un tiers, deux tiers*; the "quarters" are *un quart, trois quarts*

EXERCISE XII.

1. Write out in French: 3, 5, 7, 11, 12, 15, 19, 21, 22, 30, 31, 44, 55, 58, 60, 69, 70, 71, 80, 89, 91, 99, 100, 210, 350, 789, 911, 999, 1,234.

2. Give French for: 1st, 2nd, (two ways), 4th, 5th, 9th, 20th, 21st, 32nd, 45th, 51st, 66th, 70th, 71st, 80th, 81st, 89th, 90th, 91st, 99th, 100th.

3. 1 and 1 are 2, and 2 are 4, and 4 are 8, and 8 are 16, and 16 are 32, and 32 are 64, and 64 are 128

4. Twice 1 are 2; 3 times 2 are 6; 4 times 6 are 24; 5 times 24 are 120.

5. The minute contains (*contient*) 60 seconds.

6. The second is the 60th part (*partie*) of a minute.

7. (The) light takes (*emploie*) 8 minutes 13 seconds to come (*venir*) from the sun.

8. In an hour there are 60 minutes.

9. The day is a period (*espace*, m.) of 24 hours.

10. From midnight to midday there are 12 hours.

11. The year is composed of 365 days and a quarter.

12. The week (*semaine*, f.) has 7 days; the month has sometimes (*quelquefois*) 31 days, sometimes 30 days, and sometimes 28 only (*seulement*).

13. The month of February, the second month of the year, has 28 days

14. The year begins (on) the 1st of January; it finishes (*finit*) on the 31st of December.

15. The month of December is the last month of the year.

16. The feast of Christmas falls always (on) the 25th of December.

17. The twentieth century began (has begun) on the 1st of January, 1901.

18. What day of the month is it ? It is the 1st of December.

KEY TO EXERCISE X.

1. Il n'y a pas de grandes maisons dans ce village.
2. Ces grands arbres sont des chênes.
3. Ces enfants sont les fils de cet avocat.
4. Cette maison-ci est plus vieille que cette maison-là.
5. Cet enfant est l'élève le plus appliqué de la classe.
6. Avez-vous parlé à ce monsieur et à ces dames ?
7. Pourquoi avez-vous mis mes livres sur cette table ?
8. Votre frère a acheté ces chevaux.
9. Ce petit garçon et cette petite fille sont très aimables.
10. Je n'ai pas encore lu ces journaux.
11. Quand ces enfants sont sages leur mère est heureuse.
12. Nos parents sont nos meilleurs amis.
13. Cette demoiselle a les cheveux noirs et les yeux bleus.
14. Le garçon parle à sa mère et sa sœur parle à son père.

KEY TO EXERCISE XI.

L'histoire naturelle étudie les plantes, les minéraux et les animaux. Les plantes ou les végetaux composent le règne végetal. Les plantes sont semées sur la terre comme les etoiles dans les cieux. Les minéraux sont des corps dans l'intérieur de la terre. Les métaux sont des minéraux. Dans l'histoire naturelle des animaux une variété infinie d'etres vivants passent devant nos yeux. Les espèces d'animaux sont plus nombreuses que les espèces de plantes Les animaux les plus utiles aux hommes sont les animaux domestiques. Parmi les animaux domestiques il y a les chevaux, les ânes, les bœufs, les vaches, les brebis et les chèvres. Les chevaux sont fiers et fougueux, mais ils sont aussi dociles que courageux. Les chevaux sont plus élégants que les ânes et que les bœufs. Leurs oreilles sont moins longues que les oreilles des ânes Elles ne sont pas si courtes que les oreilles des bœufs Il y a des chevaux sauvages. Ils sont plus forts, plus légers, plus nerveux que les chevaux domestiques, mais ils sont moins utiles Les ânes sont bons, sobres et utiles. Ils sont aussi patients et aussi tranquilles que les chevaux sont fiers, ardents et impétueux. Les chiens sont aussi des animaux domestiques. Il y a des chiens sauvages, mais ils sont féroces. Ils sont aussi féroces que les loups et que les chacals. Les chèvres ne sont pas si utiles aux hommes que les brebis, mais elles sont très utiles Leur poil est plus rude que la laine des brebis. Elles sont plus fortes, plus légères, plus agiles que les brebis. Elles sont vives, robustes, capricieuses et vagabondes. Parmi les animaux sauvages les lions et les tigres sont les plus féroces et les plus cruels. Les renards sont sauvages aussi, mais ils ne sont pas si féroces que les tigres Ils sont moins féroces que les chacals. Les lièvres sont sauvages, mais ils ne sont pas nuisibles. Ils sont extrêmement timides. Les écureuils aussi sont de petits animaux fort timides. Ils sont très jolis et très intéressants. Ils mangent des fruits, des amandes, des noisettes et des glands. Il n'y a pas d'écureuils dans les champs. Ils sont dans les bois, sur les arbres comme les oiseaux.

NOTE. On page 1186, Exercise VI., the English translations of *une écurie* and *une étable* are transposed. The English for *une écurie* should read "a stable for horses"; and that for *une étable* "a stable for cattle."

Continued

GERMAN

Continued from page 1490

By P. G. Konody and Dr. Osten

XXI. The INFINITIVE PAST of the verbs is constructed of the participle past of the verb and the infinitive present of the auxiliary verb haben or ſein; for instance: laufen, to run (with ſein); loben, to praise (with haben): gelaufen ſein; gelobt haben

XXII. WEAK SUBSTANTIVES have only *one* inflection (-en or -n) in the genitive singular, which is retained in all other cases of the singular and plural. To this declension in both numbers belong only substantives of masculine gender. Feminines undergo no alteration in the singular [see VI., 2], and take the inflection only in the plural. Some neuters also take the weak inflection in the plural; but having the inflections of the strong declensions in the singular, they belong to the group of the *mixed* declension [see V., 1].

TABLE OF THE WEAK DECLENSION

		10.		11.		12.		13.	
S.	1.	der Menſch,	[the] man	der Bote,	the messenger	die Frau,	the woman	die Gabel,	the fork
	2.	des Menſch-en,	of [the] ,,	des Bote-n,	of the ,,	der Frau,	of the ,,	der Gabel,	of the ,,
	3.	dem Menſch-en,	to [the] ,,	dem Bote-n,	to the ,,	der Frau,	to the ,,	der Gabel,	to the ,,
	4.	den Menſch-en,	[the] ,,	den Bote-n,	the ,,	die Frau,	the ,,	die Gabel,	the ,,
Pl	1.	die Menſch-en,	[the] men	die Bote-n,	the messengers	die Frau-en,	the women	die Gabel-n,	the forks
	2.	der Menſch-en,	of [the] ,,	der Bote-n,	of the ,,	der Frau-en,	of the ,,	der Gabel-n,	of the ,,
	3.	den Menſch-en,	to [the] ,,	den Bote-n,	to the ,,	den Frau-en,	to the ,,	den Gabel-n,	to the ,,
	4.	die Menſch-en,	[the] ,,	die Bote-n,	the ,,	die Frau-en,	the ,,	die Gabel-n,	the ,,

1. Substantives ending in *-e*, *-el*, *-er*, take the inflection -n [table above, 11, 13]: der Löwe, the lion, *s.* 2. des Löwe-n; die Schweſter, the sister, *pl.* die Schweſter-n; die Feder, the pen, *pl.* die Feder-n;

etc. All others take -en, except der Herr, the master, gentleman, which adds -n in the singular and -en in the plural: *sing.* 1. der Herr, 2. des Herr-n, 3. dem Herr-n, 4. den Herr-n; *pl.* 1. die Herr-en, 2. der Herr-en, 3. den Herr-en, 4. die Herren.

2. To the weak declension belong all masculine substantives (*a*) ending in -e, except der Käſe, the cheese, which takes the strong declension; (*b*) those which have dropped this original final sound (der Hirt[e], the shepherd; der Schütz[e], the rifleman; der Burſch[e], the lad; der Ahn[e], the ancestor, etc.); (*c*) representatives of nationalities, countries, and towns (der Baier, the Bavarian; der Un'gar, the Hungarian; der Pommer, the Pomeranian; der Schotte, the Scotsman; der Koſak', the Cossack; der Ruſſe, the Russian; der Kaffer, the Kaffir; etc), if the denotation is not derived from nationalities, countries, towns, etc. by the suffix -er (der England-er, the Englishman; der Irländ-er, the Irishman; der London-er; der Berlin-er; der Wien-er, the Viennese; der Schweiz-er, the Swiss, [Schweiz, Switzerland]; der Holländ-er, the Dutchman)*; (*d*) many masculine substantives of foreign origin ending in -ant, -at, -et, -ent, -graph, -ik, -iſt, -og, -nom, and -oph (der Diamant', the diamond; der Prälat', the prelate; der Komet', the comet; der Patient', the patient; der Geograph', the geographer; der Katholik', the catholic; der Alkoholiſt, the alcoholist; der Geolog', the geologist; der Aſtronom', the astronomer; der Philoſoph', the philosopher).

3 Most feminine substantives belong to the weak declension All feminines ending in -el and -er (except die Mutter and die Tochter, which are strong and form the plural by modification of the vowel: die Mütter, die Töchter) take the weak inflection, whilst the masculines and neuters ending in -el and -er take the strong declensive terminations. Examples: die Kugel, the ball, *pl.* 1 die Kugel-n; der Vogel, the bird, *s.* 2. des Vogel-s, *pl.* 1. die Vögel; das Übel, the evil, *s.* 2 des Übel-s, *pl* 1. die Übel; die Ader, the vein, *pl.* 1. die Ader-n; der Adler, the eagle, *s.* 2. des Adler-s, *pl.* 1. die Adler; das Kloſter, the convent, *s.* 2. des Kloſter-s, *pl* 1. die Klöſter.

XXIII. To the MIXED DECLENSION [see V., 1] with *strong* inflection in the *singular* and *weak* in the *plural* belong several *masculine* and *neuter* substantives (the feminines take no inflection in the singular). Some of these nouns are:

(*a*) The masculines: der Gevatter, the godfather; der Lorbeer, the laurel; der Muskel, the muscle; der Nerv, the nerve; der Pſalm, the psalm; der Sporn, the spur; der Schmerz, the pain, grief; der See, the lake; der Staat, the state; der Stachel, the sting; der Strahl, the ray; der Unterthan, the subject; der Vetter, the cousin; der Zierat, the ornament; der Zins, the rent, the tax; etc. Der Dorn, the thorn, der Maſt, the mast, and der Pfau, the peacock generally take the weak plural with the suffix -en, but may also form the plural by taking the suffix -e: *pl.* 1. die Dorn-en (Dorn-e), die Maſt-en (Maſt-e), die Pfau-en (Pfau-e).

(*b*) The neuters: das Auge, the eye; das Bett, the bed; das Ende, the end; das Hemd, the shirt; das Leid, the grief; das Ohr, the ear; das Weh, the woe, anguish; and several nouns of foreign origin: das Inſekt', the insect; das Statut', the statute; das Juwel', the jewel; etc.

(*c*) Masculines of foreign origin with *unstressed* final syllables ending in -l, -n, -r. For instance: der Kon'ſul, the consul; der Dä'mon, the demon; der Dok'tor; der Profeſ'ſor, etc.; *pl.* die Kon'ſuln, die Dämo'nen, die Dokto'ren, die Profeſſo'ren. Note the change of stress where the plural is formed by the suffix -en. Substantives of foreign origin with the stressed termination -or take the strong declension with the suffix -e in the plural [XVI., 2, *c*] *without* change of stress: der Humor', the humour; der Korridor'; das Meteor', etc.; *pl.* die Humo're, die Korrido're, die Meteo're, etc.

(*d*) The masculines: der Friede (Frieden), the peace, der Funke (Funken), the spark, der Gedan'ke (Gedanken), the thought, der Glaube (Glauben), the faith, der Haufe (Haufen), the heap, der Name, (Namen), the name, der Same (Samen), the seed, der Schade (Schaden), the damage, der Wille, (Willen), the will are used alternately with both terminations, but the first form always takes the strong declension of the form in brackets: *s.* 1. der Name (or Namen), 2. des Namen-s, 3. dem Namen, 4. den Namen; *pl.* 1. die Namen, etc. Another noun with similar irregular declension is das Herz, the heart, *s.* 2. des Herz-ens, 3. dem Herz-en, 4. das Herz; *pl* 1. die Herz-en, etc.

XXIV. COMPOUND TENSES OF VERBS are formed by the aid of the corresponding auxiliary verbs of tense, haben, ſein, and werden.

1. The perfect is formed by the *past participle* of the verb [see XIV.] and the *present imperfect* of its auxiliary verb [see Table V., p. 746].

2. The pluperfect is formed by the *past participle* of the verb [see XIV.] and the *present imperfect* of its auxiliary verb [see Table V., pp. 746–7].

EXAMPLES: laufen, to run (strong verb conjugated with ſein*), past participle: ge-lauf-en, [see XIV.]; loben, to praise (weak verb conjugated with haben), past participle: ge-lob-t, [see XIV.].

Present indicative of ſein: ich bin; subjunctive: ich ſei; imperfect indicative: ich war; subjunctive: ich wäre. Present indicative of haben: ich habe; subjunctive: ich habe; imperfect indicative: ich hatte; subjunctive: ich hätte.

	Indicative.	*Subjunctive.*
Perfect *:	ich bin gelaufen, etc.	ich ſei gelaufen, etc
	ich habe gelobt ,,	ich habe gelobt ,,
Pluperfect:	ich war gelaufen ,,	ich wäre gelaufen ,,
	ich hatte gelobt ,,	ich hätte gelobt ,,

* laufen being conjugated with *to be* in German, the literal translation of the German perfect and pluperfect would be: I *am* run, and I *was* run. Note this for all other verbs for which differing auxiliary verbs are used: (ich bin geweſen, I *am* [have] been; ich bin gegangen, I *am* [have] gone; etc)

The rest of the conjugation is easily completed with the help of Table V., p. 746, the past participle remaining unaltered.

3. The first future is formed by the present of the auxiliary verb werden and the present infinitive [IV., 2] of the verb itself.

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* These take the strong declension.

4. The second future is formed by the present of the auxiliary verb werden and the past infinitive of the verb itself. [Table V., p. 747, and XXI.]

Examples: Present indicative of werden: ich werde; subjunctive: ich werde. Past participles of laufen and leben: gelaufen and gelebt. Past infinitives of laufen and leben: gelaufen ſein, gelebt haben.

	Indicative.	*Subjunctive.*
First future:	ich werde laufen	ich werde laufen
	ich werde leben	ich werde leben
Second future:	ich werde gelaufen ſein	ich werde gelaufen ſein
	ich werde gelebt haben	ich werde gelebt haben

5. The compound forms of auxiliary verbs are formed with the help of each other. Werden is used for the future tenses of all the three: ich werde ſein, haben, werden, and ich werde geweſen ſein, gehabt haben, geworden ſein; whilst in the perfect and pluperfect ſein is conjugated with itself: ich bin geweſen, and ich war geweſen; haben also with itself: ich habe gehabt, and ich hatte gehabt; and werden with ſein: ich bin geworden, and ich war geworden.

6. The past participle of werden—*viz.*, geworden, is only employed where the verb is used independently; when used as an auxiliary verb it casts off the prefix ge- and reads: worden: Er iſt Bürgermeiſter geworden, he has become mayor; but: er iſt zum Bürgermeiſter ernannt worden, he has been *nominated* mayor.

EXAMINATION PAPER VII.

1. Which inflection is characteristic of the weak declension, and when is it taken by masc., fem., and neuter substantives?
2. Of which gender are the nouns that generally take the weak declension?
3. Which substantives take the weak inflection with the vowel, and which without?
4. Which substantives denoting nationality, citizenship, etc., take the weak and which the strong declension?
5. What is the main feature of the mixed declension? Of which gender are the nouns belonging to it, and why can substantives of one gender never range in this group?
6. Which weak masculine nouns ending in -e are also used with another termination, and which are the inflections taken by both forms in the declension?
7. Which weak substantives have an irregular declension, and what are their inflections in all cases?
8. To which declensions belong the substantives ending in -el and -er, and what are the exceptions?
9. In which masculine nouns of foreign origin is the stress displaced in the plural? Which is the declension of those with the unstressed, and which of those with the stressed termination -or?
10. Is there any difference in the formation of the perfect and pluperfect of verbs in English and German? Are the same auxiliary verbs employed for this purpose in both languages?
11. Which auxiliary verbs of tense are used in the formation of the perfect and pluperfect of verbs; which in that of the first future; and which in that of the second future?
12. How do the auxiliary verbs of tense themselves form their compound tenses?
13. What difference is there in the use of the two forms of the past participle of the auxiliary verb werden?

Exercise 1. (*a*) Form the *nominative plural* of the following substantives:

der Affe, der Kna'be, der Graf, der Bär,
the monkey, the boy, the count, the bear,
der Löwe, der Bauer, der Ra'be, der Held,
the lion, the peasant, the raven, the hero,
der Narr, der Ha'ſe, der Ochſe, der Baier,
the fool, the hare, the ox, the Bavarian,
der Ungar, der Sachſe, der Grieche, der Türke;
the Hungarian, the Saxon, the Greek, the Turk;
die Ku'gel, die Mau'er, die Blu'me, die Na'del,
the ball, the wall, the flower, the needle,
die Fe'der, die Trom'mel, die Katze, die Löwin,
the pen, the drum, the cat, the lioness,
die Grä'fin, die Wöl'fin, die Bäu'erin,
the countess, the she-wolf, the peasant woman,
die Franzö'ſin, die Eng'länderin,
the Frenchwoman, the Englishwoman,
die Italie'nerin, die Zahl, die Poſt, die Freude,
the Italian woman, the number, the post, the joy,
die Tu'gend, die Frau, die Pflicht, die Geſchichte,
the virtue, the woman, the duty, the history.

Of the substantives enumerated in XXIII., *a*,

(*b*) Insert the missing declensive terminations:
die Farbe des Auge..; die Strahl.. der Lamp...
the colour of the eye; the rays of the lamps;
die Muskel.... und Nerv... des Menſch...;
the muscles and nerves of man
die Schönheit des Lor'beer...; er ruhte auf (3) ſeinen
the beauty of the laurel; he reposed on his
Lorbeer...; die Pflicht... des Unterthan...; die
laurels; the duties of the subject; the
Unterthan... der Fürſt... und der Fürſtin...;
subjects of the princes and of the princesses;
im Schatte.. des Forſt... [der Forſt... *pl.*];
in the shadow of the forest [of the forests *pl.*];
die Macht des Glaube... kräftigt (4) die Herz...;
the might of faith strengthens the hearts;
der Überzug des Bett... [der Bett...] iſt herrlich;
the cover of the bed [of the beds] is magnificent;
die Stärke des Wille... bricht oft die Kraft des Leid...
force of will breaks often the strength of woe
und des Schmerz...; die Leid... und Schmerz...
and of pain; the aches and pains
waren ſchrecklich; die Form.. des Ohr.. ſind verſchieden;
were terrible; the forms of the ear are different;
die Töch'ter des Direk'tor...; rufe d.n
the daughter of the director; call [thou] the
Herr...; die Direktor... reiſten mit (3)
master (gentleman); the directors travelled with
dem Graf...; die Frau des Schott...; die Peitſch...
the count; the wife of the Scotsman; the whips
des Koſak...; er reiſte mit (3) einem Baier...,
of the Cossack; he travelled with a Bavarian,
einem Grieche... und mehreren Ungar...
a Greek, and several Hungarians.

Continued

Group 26

SHOPKEEPING

11

Continued from page 1421

CYCLOPÆDIA OF SHOPKEEPING

BUTTERMEN. Varieties of Butter and their Qualities. Butter and Margarine. Prices and Profits. The Shop

CARPET MERCHANTS. Capital Required. Premises and Fittings. Stock and Side Lines. Buying and Selling

BUTTERMEN

Owing to the increasing consumption of butter and the enormity of our imports, the retailing butterman is becoming more and more a special institution. The establishment of shops by wholesale firms in all parts of the country, and the increased competition for trade has been followed by a general reduction in prices of all inferior brands and by the manufacture of an article which contains double the normal quantity of water. For these reasons the prospects of those who propose to enter the business are not particularly promising. We believe, however, that by straightforward trading, by making a speciality of fine home brands, by giving fair weight and exacting only a just charge for what is sold, the business can always be made sufficiently profitable. Consumers require uniformity in quality; hence, whatever the brand sold, uniformity must be maintained. Butter produced on the farm differs often from week to week, and if farm butter be sold, it usually becomes necessary to purchase it from a variety of makers, with the result that in each case there is a variation in colour, flavour, or texture. The retailer is, therefore, driven to the factory, the creamery, or the importer of imported brands.

Classes of Butter. In the first place, the retailer must be expert, capable of recognising and valuing any brand or make of butter, and the country of its origin; and, further, he should be in a position to know whether it will keep. A high-class trade pays best, but, while choice brands may be kept to suit wealthier customers, cheaper brands may be consistently sold to suit the requirements of the working classes. Thus, one of the first objects should be to secure a weekly consignment from one or more reliable makers of the finest English butter, preferably that produced from the milk of Jersey or Guernsey cattle, or from herds of cows in which these animals predominate. At this moment it is almost impossible to secure such butter in the retail trade. Samples may be examined at the National Dairy Show and the chief agricultural exhibitions, and the addresses of the makers obtained, but before concluding an arrangement the farms where they are made should be inspected, and personal relations cultivated. This butter should be carefully weighed, packed in grease-proof paper in neat rolls and tastily made up and finished. It should be rich in colour, firm in texture, mild, sweet, and nutty in flavour, and if always alike, it will not only capture, but retain, custom and gradually make its way. For a general middle-class trade the best Danish and Norman or Brittany rolls, Irish creamery and English factory, will suit the customer best; but consignments should be frequent, and care taken to prevent the sale of a single pound in which the flavour has depreciated by keeping. Doubtful makes, such as Dutch, German, and Siberian, had better be left alone. Second and third class qualities of the makes just recommended may be kept for sale to the poorer class of customers. To these may be added the finest Australian obtainable. The market should be watched from day to day, and advantage taken of any reduction.

Buying. Again, one of the certain methods of securing a fair profit is that of paying cash and securing the trade discount. The importer or butter merchant is induced to do his best to please a customer upon whom he can always depend for immediate payment. Nothing, however, is of greater importance in the butter trade than a guarantee on every invoice that the article sold is pure. This should be insisted upon. Again, butter, like all similar goods, should be kept clean and exposed to the air as little as possible. The atmosphere is filled with dust and germ life, both of which are deposited upon and necessarily adhere to a food like butter, which rapidly taints in consequence, while exposure to air and light rapidly changes its outside colour.

One of the chief needs in the equipment of a butter shop is a cold room, especially in warm weather, when decomposition is so rapid, and when customers are easily lost by the sale of a tainted sample. Butter purchased sweet when prices are low may be kept with double advantage under these conditions.

The buyer should never be deceived by notices, which are too commonly exposed in shop windows, in which second and third qualities are frequently described as "Best creamery," "The finest made," "The best dairy," "No better sold," and the like. This practice, often a dishonest one, is growing, and while it may mislead the ignorant, it can be followed only by a loss of the best class of customers, who are willing to pay for quality and who easily recognise the petty fraud to which they are frequently subjected.

Margarine. Apart from what has already been said, the quality of the goods sold should be adapted to the neighbourhood in which the trader resides. It may be necessary to keep margarine, but the greatest care is necessary to prevent salesmen making the mistake of selling one article for another or of labelling margarine with a card upon which it is described as butter. A purchaser should never be refused, for he may turn out to be an inspector. Under the existing law sampling is provided for, and no mixture of margarine with butter is permitted; margarine, indeed, is a mixture of butter and a fat known as oleo, which is not produced from the milk of the cow. Nor must butter contain an excess of water, although the law has not yet established a fixed percentage. To be on the safe side, however, no butter should contain more than 16 per cent. unless the fact is announced by label or word of mouth. If butter which has been blended with milk is sold, the fact must be shown by label, together with the percentage of water present.

Prices and Profits. Butter varies in price almost more than any other class of food In the English market town prices range from 8d per pound in summer to 1s. 2d. in winter. London market prices range higher, inferior brands being useless in the wholesale trade. Danish butter ranges higher than Irish by 7s to 10s per cwt., the former varying from 1s. to 1s. 3d. by the lb, and the latter from 11d. to 1s 2d.; Australian, Canadian, Argentine, Dutch, and Russian are all at least a penny a pound lower than the above. Good samples are often found among Australian consignments, while of French imports the most important come from the blending houses of Normandy and Brittany. The best of these are fine and mild, while the inferior brands do not keep well The best imported butters come from Denmark—these are uniform and keep well.

Although the cheaper butters are cut low in price owing to competition, the profit of the retailer is seldom less than 1½d and 2d per lb., the average profit as obtained by the ordinary trader ranging from 2d. to 3d. per lb Where butter is made up into rolls by the maker there is no allowance necessary in surcharging for profit, inasmuch as there is no turn of the scale to be provided for. Where, however, the retailer weighs out each parcel for his customer he frequently adopts the objectionable practice of making it up behind a screen and incorporating water, or deftly gives short weight and so provides for the turn of the scale.

The Shop. In equipping a shop great pains should be taken to make it look tasty, inviting, and clean. If the trader can afford the expense involved, he will do well to take a trip to Paris and examine some of the most daintily equipped establishments in which butter and kindred goods are sold. His requirements should be explained to a firm experienced in shopfitting, but he will necessarily adapt himself to his means. His premises should be selected in a busy thoroughfare, and on the side of the street which buyers frequent for shopping. He must then depend upon the quality of his goods, moderation in price, attention to the requirements of customers, straightforward dealing, and the invariable practice of keeping his word

CABINET MAKERS

The commercial side of retail cabinet-making is discussed in the article on House Furnishing, which appears later in this course. The practical side of cabinet-making receives attention in another section of the Self Educator.

CARPET MERCHANTS

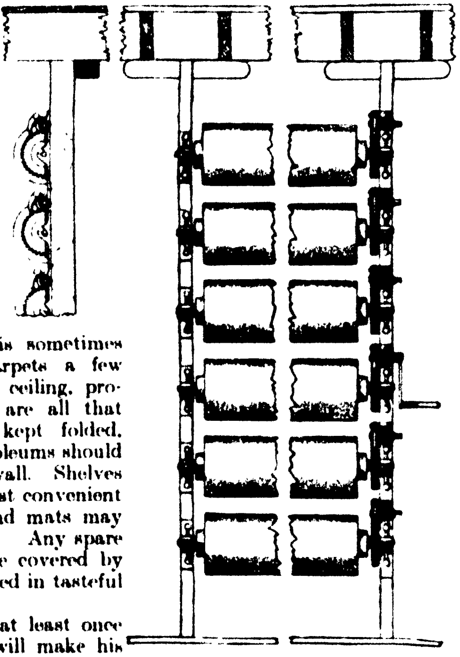
It must be clearly understood that no novice can make a success of the carpet business. Before starting for himself a man must, to achieve success, secure as good an all-round experience of carpets and furnishing drapery as possible. This experience may be obtained in the carpet department of the large drapery houses or in the shop of some retailer with a good going business. Moreover, the carpet merchant must have good taste, and a true eye for colour, so that he may be able to advise customers regarding harmonious combinations, and also make an attractive window show, with no bizarre effects. It is not advisable nowadays to start business in a small way with carpets only. These must be supplemented by rugs, mats, linoleums, felts, trimmings, blinds, window curtains and other furnishing necessities.

Capital Required. Assuming that our young man with carpet-dealing aspirations is of good character and is well known to the wholesale houses, he may make a very creditable start in the retail business with a capital of from £400 to £500 With this sum it must be understood that the business he contemplates is a medium-class one in the suburbs or in a provincial town. With ability, carefulness, and, most important of all, a good knowledge of the trade, he will in the majority of cases build up a profitable and, in some cases, a lucrative business His trade must, first of all at least, be for cash only

There are three distinct classes of trade to be done, all more or less dependent on the neighbourhood, on personal inclination, and on capital at disposal. The first is the high-class trade, confined mainly to artistic effects, self-colours, and Oriental designs; the medium, including a little of that mentioned, but more of the everyday style of goods; and the cheap and showy class. The man with £500 and the other requisites we have mentioned is well qualified for the medium class.

Selection of Premises. The utmost care should be taken in selecting a suitable shop. A medium-class trade having been decided upon, a shop must be looked for in a busy street, next door to a draper, for preference, who has attractive windows and no carpet department. But the fact that the draper neighbour has a carpet department need not necessarily cause alarm. In such a case the carpet man must see to it that his wares are a "cut above" those of his neighbour. The important point is to settle in a neighbourhood of attractive shop windows and a busy promenade. A good window is one of the first requisites of the carpet business. It should come to within a foot of the ground, and be at least 10 or 12 ft. from front to back. It must be remembered also that the greater the floor space obtainable the better, as the goods are bulky, and need room for their display.

Fittings. The fixtures required are very simple, and a handy man, with an aptitude for carpentry, could easily fix up the shelves required for himself. All that is necessary is a few lath partitions for keeping the stock, and some brass rods or poles on which to hang light goods. Nothing in the way of elaborate interior decoration is required, for the carpets, rugs, linoleums, and so forth, in a diversity of patterns and colours, are the best decoration possible. The linoleums will stand well enough by themselves, although for unwieldy and for very long rolls a warehouse rack such as that illustrated—which is a design by Messrs. M. Nairn & Co., Limited, of Kirkcaldy and London —is a valuable time saver. It must be well and strongly made, as the weight it has to sustain is sometimes very great. But for rolled carpets a few upright partitions from floor to ceiling, projecting about 2 ft. from the wall, are all that is needed. Oriental carpets are kept folded, but other seamless carpets and linoleums should be stood on end along part of the wall. Shelves about 3 ft. deep will be found most convenient for the breadth goods, and rugs and mats may be kept folded on the lower shelves. Any spare wall space may with advantage be covered by hanging carpets and rugs, arranged in tasteful style.



ARRANGEMENT FOR STOCKING LINOLEUM AND FLOORCLOTH

The window should be dressed at least once a week, and the far-seeing man will make his window displays a feature of the neighbourhood. A window with all the goods therein in shades of rose, green, or blue, is magnetic in its attraction, but care must be taken that the shades harmonise. The remarks on colour harmony on page 510 may be noted. Turkey colours make a good window display, but what are known as ordinary Oriental designs are the most easy to use, as they invariably harmonise with each other.

The rent which the beginner would pay for such a shop in a town of good size need not be more than £90 per annum, and the fittings should not cost more than £30. The best time to start is about February, for the "season" begins early in March, when the housewife turns her thoughts towards that family bugbear—"spring cleaning."

Staff. To begin with, the proprietor will, if possible, live on the premises. A man who has learned his trade properly will be able to measure for, and, if necessary, lay carpets and linoleums, and this he will do at first himself, so that all the help he requires will be a good strong errand boy to deliver the goods. With an increasing business, however, he will find it advantageous to engage a handy man who can plan, cut, take measures, hang blinds and curtains, and lay carpets. There are many such useful men in the trade who may be secured at from 30s. to 35s. a week. The proprietor would thus be free to attend to customers, and he would have a reliable person to leave in charge of the shop during his absence—for it must be remembered that he must seek for business out of doors. Where removals are, there he should be, keeping a keen eye on the new-comers to the neighbourhood who may want house furnishings, and unobtrusively and politely letting the public generally know that he is the man for their needs. As soon as trade will permit, it is advisable to employ a woman to sew up new carpets and to alter old ones. In her spare time, if she has any, she may be profitably employed sewing on tickets, dusting, arranging the small things, and doing other light work.

Stock. Small capital necessitates a limited and carefully selected stock. It is perhaps best to keep at first to seamless carpets, or to those made on what is known as the Chlidema principle. By this is meant that the carpets are constructed in breadths each of which is a complete pattern, and carpets of any size may be made by sewing these breadths together. A few breadths of different patterns will, therefore, be necessary. Samples of ordinary breadth carpets which are kept in stock by manufacturers can easily be obtained, and in most cases these will be left on show for some months, and if orders are obtained, a fresh selection will be sent from time to time. This applies practically to all the recognised makes of carpets (except Orientals), and to felts and linoleums. Supposing that £300 is spent on ordinary stock, it would be apportioned somewhat as follows: seamless Axminster carpets, £50; Brussels squares, £30; Wilton squares, £20; Roman squares, £30; rugs, £20; mats, £10; felts, £15; Axminster stair-carpetings, £30; Brussels stair-carpeting, £20; linoleums, £55; and sundries, £20. If there be no one in the neighbourhood who sews up body-carpeting, there are several planners in London and other large centres who work for the trade, and, failing these, the manufacturers will in most cases undertake to get the work done for the retailer.

A very good show may be made with such a stock, especially when it is borne in mind that this by no means represents the retailer's resources. It is not essential that stock be kept of such things as window blinds, trimmings for furniture coverings, and so forth. A fine selection of samples in innumerable patterns will be supplied by wholesale houses. This applies also to serge for tablecloths, ball fringe, and cretonne bandings. A box of about 100 samples of these involves no outlay of capital, and gives a large selection to the customer. Manufacturers will supply pattern books of linoleums, floorcloths and felts, and orders for all lengths will usually be executed by return.

"Orientals." Oriental carpets are usually obtainable on sale or return. If the money will run to it, and the neighbourhood be favourable, a show might be made with a few Turkey, Persian, Indian, Japanese, and Chinese carpetings —all of which are classed under the head of Orientals. A sum of £30 thus spent would give a profusion of colour to the new establishment. Roman squares, or art squares, as they are often called, are very popular nowadays. In rugs the principal things to select are hearth-rugs, bedroom rugs, and skin rugs. The stock will have to include felts in green, blue, and crimson, and plain felt for "surrounds," besides underfelts for putting beneath carpets for rooms and stairs. The general widths for stair-carpets are 22½ and 27 in. Chinese, Indian, and Japanese mattings are cheap, make a big show, and sell quickly.

Side Lines. As a rule, carpets are sold along with other "soft goods," such as furniture coverings, curtain materials, blinds, and, if successful, this branching out can be carried to great length, and will increase the profits. These things include piece muslins, casement cloths, Nottingham, Swiss, and net curtains, Madras muslins, etc., of which a fair selection can be obtained for £25. Then there are fancy cushions (a few of which add to the attraction of a window display), table-covers, tablecloths, piece tapestries for furniture coverings, curtain damasks, plain serges (for table-covers and for portières), cretonnes and chintzes, all of which will absorb another £40. Lastly, about £15 worth of general trimmings, such as curtain-loops, tie-backs, etc., will be found necessary. Other oddments not to be neglected are Japanese screens, Japanese tea-trays, paper-baskets, workbaskets, all of which cost little. Hassocks are made up from waste cuttings. Waste mitres from the corners of the borders of breadth carpets are made up into scuttle-mats, while odd Brussels cuttings may be made up into slippers.

Credit, Prices, and Profits. The man with a good record and a banking account will have little difficulty in getting assistance in the way of credit from the wholesale houses. These are matters of arrangement, and vary according to the circumstances, but the usual credit terms may be put at from one to three months.

The average profit on carpets proper may be put down at from 20 to 25 per cent. on the return for the regular selling qualities. Brussels, Axminster, tapestry, and Wilton carpets sold by the yard are much cut in price, and if one of these carpets cost, say, 2s. per yard, it would have to be sold at probably not more than 2s. 6d. per yard. Thus, a bordered Chlidema carpet, nine feet square, that sells at 36s. would probably cost about 28s. A seamless Kelmscott of the same size selling at £2 would cost 33s., and so on. Naturally, as one gets into the finer and more expensive grades profits are higher in proportion, but the beginner would have to stock at first the ordinary sellers, and look for his recompense on the foreign makes—Indian, Turkish, Persian, etc. Large carpet dealers protect themselves against this "cutting" by getting makers to confine certain patterns to them, and if a particularly select pattern is thus restricted to a specific dealer, the latter can, of course, secure an enhanced profit. On foreign carpets one may look for a 33⅓ per cent. profit on the return, but the odd lengths of yard goods must always be kept in consideration, for on these probably only 10 to 15 per cent. would be obtained.

In buying carpets, as in other things, the retailer should always keep a keen eye on the bargains to be picked up from the makers, and the smart buyer will often more than counterbalance his losses in this way. The general discount to retailers on a monthly account is 2½ per cent. off wholesale prices. In some cases discounts even up to 5 per cent. may be secured, and in rare instances 1¼ to 2½ per cent. more may be given for cash paid on delivery. But 2½ per cent. off the wholesale price, payable in a month, 1¼ per cent. for two months' credit, and net prices after three months, may be regarded as the rule. The profits on the furnishing draperies and other sundries are about 33⅓ per cent., and the skilful man will easily even up his total by a judicious pushing of the more remunerative lines.

Linoleums. The chief market in linoleums and floorcloths is in the cheap varieties costing from 6d. to 1s. a square yard, and yielding profits of from 2d. to 4d. or 6d. a square yard. The higher qualities of surface pattern linoleums have been killed by the inlaid patterns—so called—which retain their patterns until worn to the canvas backing. It is probable that inlaid linoleum will be made in ever cheaper and cheaper qualities. At present retail prices range from 3s. to 4s. a square yard, showing a profit of 20 to 30 per cent. Occasions often arise of buying "job" linoleums—*i.e.*, short length remnants or pieces with slight faults—at a good deal less than regular prices. Some new firms are even given to manufacture "jobs"—that is, to sell perfect goods as job, so as to maintain output and get into the market. Such occasions constitute the buyer's opportunity.

Continued

Group 1

AGRICULTURE

11

Continued from page 1390

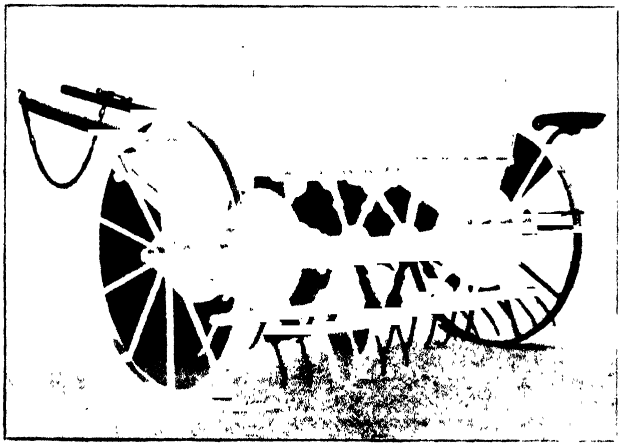
HAY AND HAYMAKING

Nature and Uses of Hay. Qualities of a Good Crop. Chemical Constituents. Cutting the Crop. Processes Involved in Haymaking

By Professor JAMES LONG

HAY is produced from the mixed herbage of the meadow—from clover, mixtures of clover and particular grasses, from rye grass, timothy grass, both of which are occasionally sown alone, from lucerne, and from sainfoin—by the aid of the sun and the wind. When green oats, rye, or vetches, are cut and dried in a similar manner, they are also frequently described as hay.

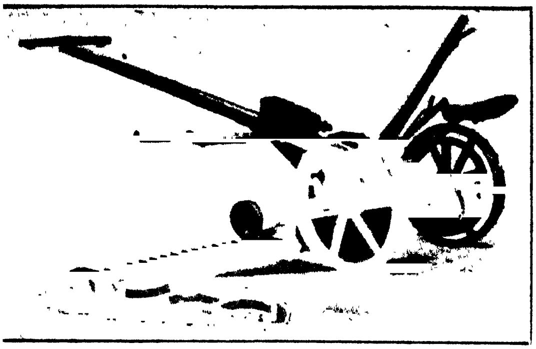
The dried grass of the meadow is known as meadow hay; hay of other kinds is usually described as mixture where the plants composing it are mixed, or by the name of the particular plant which has been cut. Hay is chiefly employed as a food for horses, cows, and sheep. Growers within reasonable distances of large towns send their best hay to market in trusses of 56 lb. each, 36 trusses forming a load. The trussed hay which has been pressed weighs volume for volume 50 per cent. more than hay trussed by hand. When hay is cheap, as it has been for some few years, it returns a very small profit to the grower, the average English yield being only 24 cwt. to the acre in the case of meadow hay, and 20 cwt. in the case of clover and other artificial grasses. When less than 50s. a load is realised for a good sample it is wiser to feed the crop to stock on the farm. Hay is not likely to rise seriously in price in the near future owing, in part, to the fact that with a substantial rise large consignments are sent from abroad, thus ensuring a fall, and, in part, to the fact that the motor-car is so largely taking the place of the horse. In grass counties, as in the West of England, hay forms the chief winter ration of the cow and the flock; in arable counties meadow hay is but little grown, the cattle being chiefly fed upon roots, straw, cake, and corn.



HAY TEDDER

Qualities of Good Hay. The best hay is produced from early-cut grass. The great majority of farmers prefer to cut later in the hope of obtaining a greater weight per acre; but this extra weight, tangible though small, is accompanied by inferiority in the quality. The seeds are in large part formed in late-cut grass, and, although small, contain the chief feeding properties of the plant, but they are largely shed. What therefore remains in stem and leaf is tough, stringy, and little better than straw. Good hay should not only be highly nutritious, but fragrant, green, and tender, and this may be secured while the grass is still young and succulent. When grass is cut early, a larger and much more valuable after-growth is obtained, while the work of the farm is advanced. On the contrary, when it is cut late, not only does the quality suffer, and consequently the market value of the crop, but the after-growth in dry seasons becomes very scanty. The fragrance of hay depends partly upon the grasses of which it is composed, partly upon the skill exercised in making, and partly upon proper heating in the stack. Greenness is secured chiefly by wind-drying. When the sun is powerful, hay is easily bleached unless it is quickly handled and carried, but even then the colour is not so perfect as when it is dried chiefly by the aid of a warm wind. There are many buyers who prefer brown hay—*i.e.*, hay which has been sun-dried and properly heated in the stack.

Effect of Rain and Time. Both colour and fragrance as well as feeding value are lost where hay has been wetted by rain, or when it is carried and stacked before it is sufficiently dry. If carried when too dry, fragrance and succulence are lost altogether with colour and flavour. Rain, however, is the greatest enemy to hay, inasmuch as it not only washes out the soluble albuminoids and other feeding materials, but there is a danger of mould in the rick. Old hay is fuller in fragrance and deeper in colour than new hay, and as with time

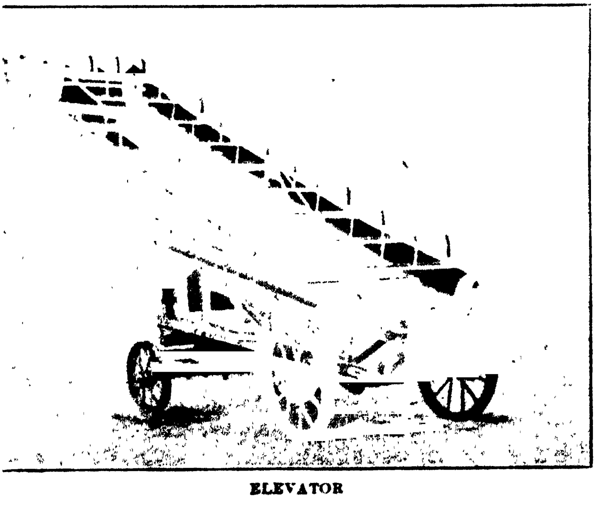


MOWING MACHINE

settles in the rick, it weighs more per cubic oot. Apart from the points to which we have eferred, the quality of hay depends upon the erbage from which it is produced. There should, or example, be no plantain, Yorkshire fog, dock, napweed, and little of the inferior grasses. In ll samples of meadow hay, clovers should form a arge proportion. The feeding value of hay may e estimated from the following analyses:

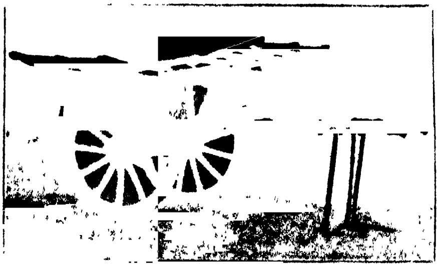
ANALYSIS OF VARIOUS HAY CROPS

	Water	Ash	[illegible]	Digestible Matter			
				[illegible]	[illegible]	[illegible]	[illegible]
	Per Ct	Per Ct	Per Ct	Per Ct	Per Ct	Per Ct	As 1 to
Meadow Hay							
Poor	14·3	5·0	80·7	3·4	34·9	0·5	10·6
Good	15·0	7·0	78·0	7·4	41·7	1·3	6·1
Red Clover							
Poor	15·0	5·1	79·9	5·7	37·9	1·0	7·1
Good	16·5	7·0	76·5	10·7	37·6	2·1	4·0
Lucerne (good)	16·5	6·8	76·7	12·3	31·4	1·0	2·8
Sainfoin	16·7	6·2	77·1	7·6	35·8	1·4	5·2
Trifolium incarnatum	16·7	5·1	78·2	6·2	34·9	1·4	6·2
Rye grass	14·3	6·5	79·2	5·1	35·3	0·8	7·3



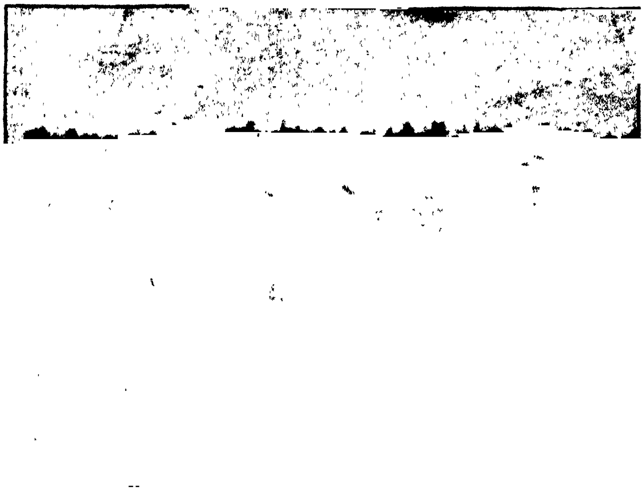
ELEVATOR

Chemical Constituents of Hay. According to Warington—a good authority—a crop of meadow hay weighing 1½ tons contains 49 lb. of nitrogen, 50·9 lb. of potash, 32 lb. of lime, and 12·3 lb. of phosphoric acid; while a 2 ton crop of red clover hay contains 98 lb. of nitrogen, 83·4 lb. of potash, 90 lb. of lime, and 24·9 lb. of phosphoric acid. Thus, the hay crop removes from the soil as much nitrogen and a great deal more potash than a crop of either wheat, barley, or oats, while a crop of clover removes nearly twice as much nitrogen, more than twice as much potash, and slightly more phosphoric acid than either of these cereal crops. The same chemist points out that a crop of meadow grass weighing 5 tons and capable of producing 1½ tons of hay contains 2,613 lb. of combustible material—carbon, hydrogen, nitrogen (49 lb.), oxygen, and sulphur—and 209 lb. of mineral matter (ash), chiefly potash, lime, and silica, the balance being water. From these figures we can practically gauge the manurial value of hay as compared with other foods. Taking cotton cake as representing 1,000, clover hay is placed at 345 and meadow hay at 235. Thus, weight for weight, meadow hay of medium quality is practically equal to the cereals, and much superior to the cereal straws, while mature clover hay is superior to either, chiefly owing to its richness in nitrogen and potash.



HAY CART

Cutting the Crop. In making clover hay it is important to collect the crop before the leaves have become too brittle, inasmuch as they break up by handling, to the great loss of the farmer. It should be a rule in cutting to mow no more than can be mastered should rain threaten. A crop had better be cut late than made in wet weather, when it is too easily destroyed. Hay under hand should be no larger in quantity than can be put into the cock at very short notice. In this form hay is practically safe from destruction unless wet weather continues. On the return of the sun, the cocks should be moved or opened, not only that the hay itself but the



CUTTING A THREE YEARS' LEY

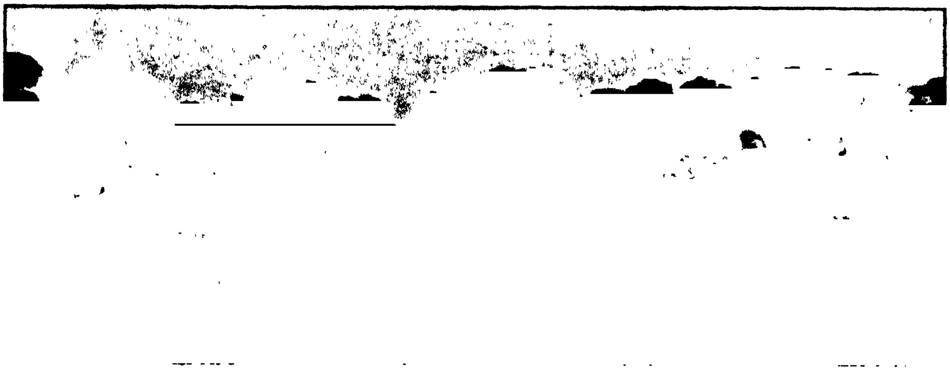
ground upon which it has stood may be dried. In parts of the north of Britain it is common to cover the haycocks with a compressed paper cap or shield. In other parts, where wet weather prevails the hay is made into small stacks weighing about half a ton. These stacks are skilfully loaded upon lorries when fit to carry, and removed bodily to the rick on to the top of which they are elevated. In Sweden, as we have seen, it is a common practice to hang grass upon horizontal poles that it may be air-dried in the absence of sun and wind, but the labour involved is considerable.

Mowing. Hay was formerly cut by the scythe, but in these latter days it is almost universally mown by a machine which practically covers an acre in an hour. The scythe makes cleaner work, and damages the hay less, but mowers are now seldom to be found, and even where they are necessary the wages they require are much too large to permit of the practice being continued. Where a crop of grass is light and the weather fine, it is often dried in a few hours, drawn into windrows with a *horse-rake*, and carted to the rick without any hand or machine work whatever. A good crop, however, after lying in the swathe sufficiently long for the upper surface to be partially dried, is turned over by men armed with forks, or by the modern implement known as the *swathe-turner*. In due course the partially-made hay is then shaken out by the men or by hay *tedders*, drawn by one horse and driven by a boy.

Raking into Windrows. It is subsequently raked into windrows, and when, in the judgment of the farmer, it is fit for the rick, the carts are loaded, it is drawn to the stack-side, and either lifted by hand, by a needle, or a pair of gripping irons fixed on a pulley, or by the commonly used elevators. Hay in the windrow, or even before windrows have been made, if it is fit, is by many advanced or progressive farmers dragged to the rick by an American sweep drawn by a pair of horses, so that hauling either by cart or waggon is unnecessary. In some cases, too, an implement which is attached to a waggon is employed to take up hay as it passes along the windrows, but the former plan may be regarded as the better.

Loading. Under ordinary circumstances, the hay is loaded into carts or waggons by men known as pitchers, one on either side, two loaders being employed on a waggon and one on a cart. In this case each vehicle is followed by rakers drawing a hand-drag, and subsequently by the horse-rake, by the aid of which the field is thoroughly cleared. In all these matters judgment is required, not only to prevent partial destruction of the crop, but to ensure quality.

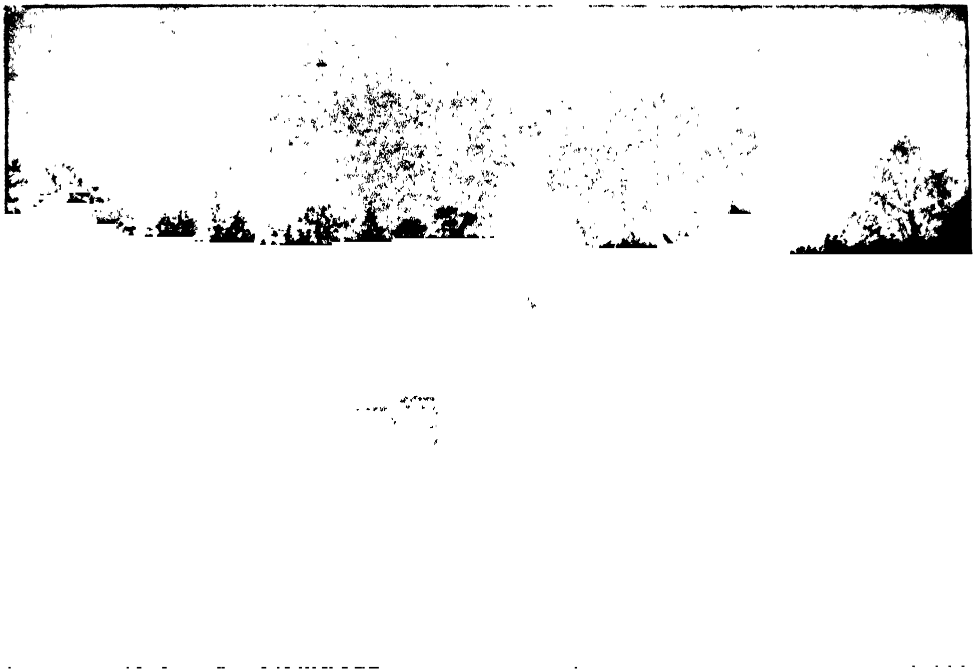
Stacking. A stack of hay varies in weight per cubic foot in proportion to its age, its composition, how far it has heated, and in accordance with the part from which



RAKING THE HAY

it is cut. Thus, in the centre of a rick, hay weighs much more than at the top or the outsides. When it is well heated, fermented, or sweated, from 8 to 10 cubic yards will weigh a ton, more being required in new hay than in old, or in loose hay than in that which has well settled down. Thus, experience is required both in selling and buying; it is consequently wiser for the inexperienced to sell by the ton rather than by the stack.

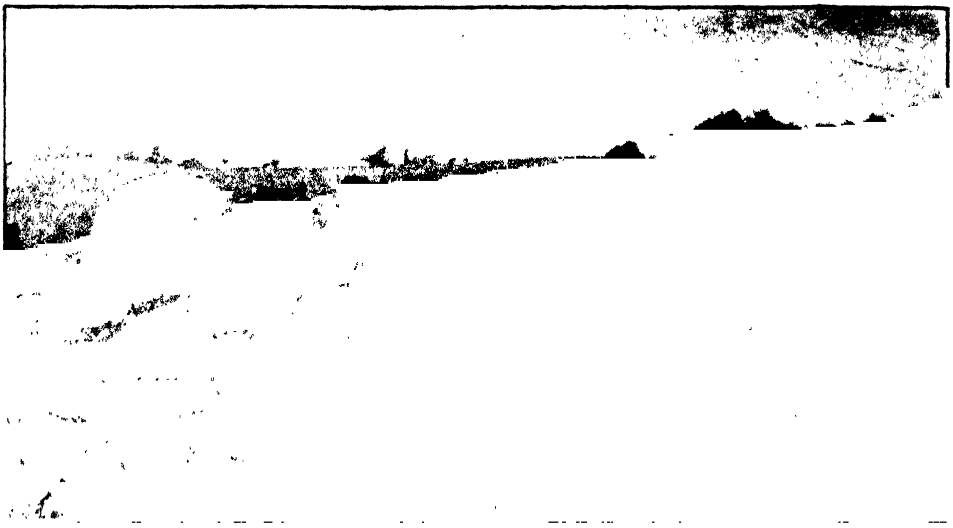
Hay Barns. Instead of being built in stacks or ricks, hay is sometimes built in hay barns. These are usually constructed of iron standards supporting corrugated galvanised iron roofs. Sometimes, however, the structures are of wood with boarded roofs, each board being slightly grooved near each edge and placed from ¼ to ½ in. from its neighbour. If hay barns are costly, they are of great economical value, for the hay is out of danger immediately it is under cover, which is not the case where the stacks are built in the open—in spite of the common practice of using waterproof sheets—until the thatch has been laid on.



HAY TEDDER AT WORK

Thatching. It is wise to prepare the thatch before the haymaking season commences. Thatching straw should be long and strong, and the produce of the wheat crop. As the straw is required, it is placed in loose heaps and well wetted. It is next drawn in yelms, or small bundles, which are carried by the assistant to the thatcher, and laid on one by one, the work beginning at the eaves and finishing at the ridge. In some districts split hazel rods are employed for keeping the thatch in position. These rods are pointed at each end, twisted and bent in the centre, and grip the straw as they are thrust into the hay on the roof, like a hairpin. In other cases, the stakes are simply media on which the thatching twine is bound, but practically the object is the same, the maintenance of the thatch in its place. Thatching is an operation which needs considerable practice and skill, good workmen being extremely scarce. It is obvious that before thatching begins the rick should have settled, and that the roof should be well raked, even, and solid, for where there are depressions, or settlements, after thatching is completed, rainwater finds its way into the hay. It is specially important that the ends of the roof should be thatched extra tight, and well finished, or wind may remove the thatch and expose the hay to damage. Thatch should be a foot thick, in which case the wheat straw required will be nearly 5 cwt. per square of 100 ft.

Cost of Cutting and Binding. The cost of cutting and binding hay for market varies from 3s. to 4s. per load averaging in round numbers 1d. a truss, the sum usually paid for the rough hay left on the farm. Clover hay is frequently bound with straw bands; this improves its appearance, and is more economical. Hay growers adjacent to large cities usually load their carts over night, the men leaving home in time to reach the market early on the following morning. In the various hay markets hay is sold on behalf of the owner by salesmen, who are paid by commission, which they deduct with the

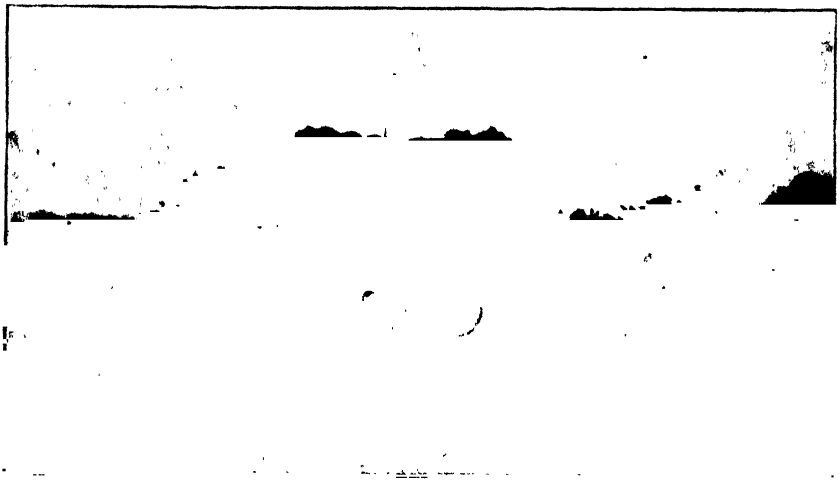


CARTING HAY

market toll, if any, from the sum realised. Salesmen, however, should be instructed to sell all consignments in the market, and never to send them direct to customers. Handsome profits are often made by experienced men in buying hay by the rick; the seller, however, should be guarded in pitting his own judgment against the greater experience of the hay dealer.

Meteorological Society. During the haymaking season some assistance may be obtained by subscribing to the Royal Meteorological Society for daily telegrams forecasting the weather. In the present state of our knowledge, however, we are bound to say that it is not wise to place too implicit a faith in forecasts. Nevertheless, the charge is so small that a single day's help in this direction may be sufficient to save some acres of hay, the salvage of which might not otherwise have been attempted.

Continued



HAY LOADER

ACTION OF FLOWING WATER & ICE

Erosive and Transporting Action of Running Water. Deltas and their Formation. Glaciers and their Important Work. Moraines

Group 14

GEOLOGY

9

Continued from page [illegible]

By W. E. GARRETT FISHER

We have already seen that a part of the rain which falls upon the surface of the earth sinks underground, and there performs important geological work. But a great deal of the water which is precipitated from the atmosphere does not sink into the ground, but remains on the surface, in the forms of brooks and rivers, which run into lakes or into the sea. This running water performs a very important work of erosion on the surface of the land; it has done much in the past, and is doing much in the present, to mould the contours of the landscape. In those few parts of the world where the surface is a dead level the rain accumulates in pools, which ultimately either sink into the ground or evaporate into the sky. But in most places where rain falls the surface is not level, and the rain, obeying the law of gravitation, runs down the nearest slope

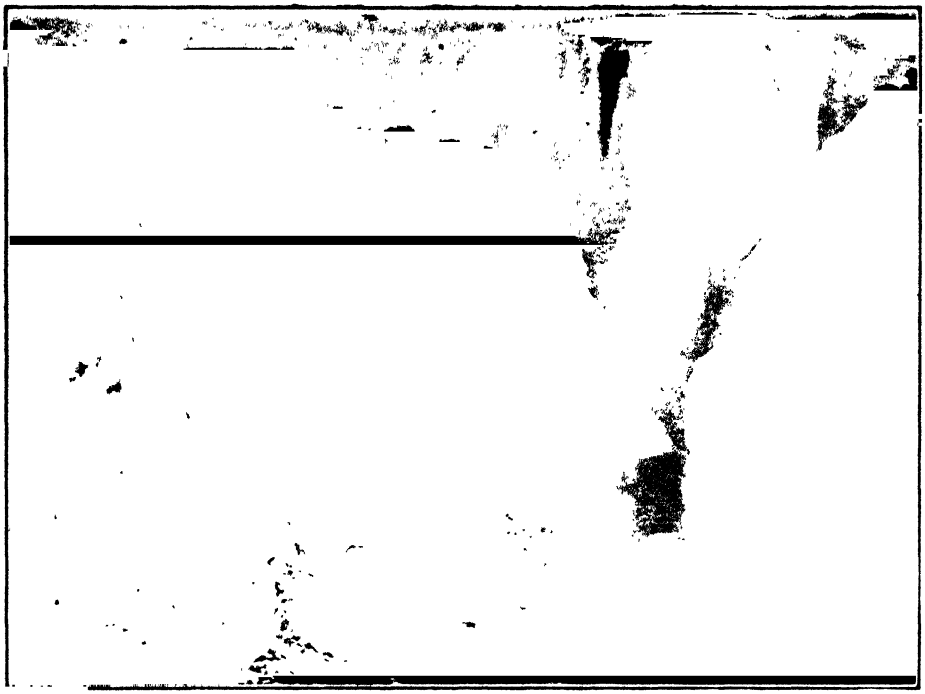
Running Water. If we watch the rain falling on a mud bank or on the sandy surface of the seashore, we see that it traces little valleys in the soft ground, whose size and direction are conditioned by the slope of the surface and the nature of the soil. Stones or harder portions of the surface cause the running streams to divide or ramify into a network, and a miniature river system, with tributaries, watersheds, and affluents is thus produced. It is precisely in such a fashion that the great river systems of the world have come into existence, and that valleys and gorges have been carved out of the hills or tablelands of the more primitive rocks.

We can see on every hand examples of the way in which running water carves its course along the earth's surface. This it does in virtue partly of its own motion and partly of the sandy or gritty materials which it carries in suspension. When water flows along the surface of a soft and friable soil, it washes away the superficial portions and carries them along in mechanical suspension with a force directly proportional to its speed and to the size of the grains which compose the soil. A rapidly-flowing river or a torrent going down in spate is capable of transporting large pebbles, or even small boulders, which are usually dragged along the bottom of the watercourse, and thus act as a plough excavating the soil over which they pass. The speed and extent of the work of excavation depends also upon the nature of the ground. A river takes a long while to carve its way through solid granite, whereas it may very rapidly wear a gigantic valley in soft, sandy, or muddy rocks.

Rivers Make Their own Valleys. There is a great deal of evidence to show that the valleys through which all large rivers run have been actually carved out by the rivers themselves. They vary immensely in size and character, according to the speed and volume of the river and the nature of the rock through which they have been worn. The gigantic gorge of the Colorado and the tiny trough of a Hampshire trout stream seem, at first sight, to have little in common, but they are both equally the product of the same instrument.

Erosion by Running Water. The actual erosive power of running water is best illustrated, of course, by a waterfall or torrent. Everyone is familiar with some example of the gorges cut on a small or gigantic scale by running water on the hardest rocks. One of the finest examples in the world is that of the Niagara River, which plunges in its world-famed falls over a mass of hard limestone, under which lie soft shaly beds. These falls, at present, stand about seven miles above the mouth of the Niagara River, and there is abundant evidence to show that at one time this river fell over a cliff which formed the shore of Lake Ontario. The erosion of the water, aided by the stones which it carries down and the ice

57. POT-HOLE IN GLACIER GARDEN, LUCERNE

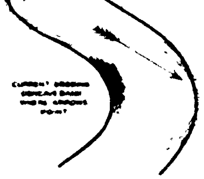


58 THE WATER-WORN GORGE AT THE VICTORIA FALLS

Wilson

of winter, has gradually worn the cliff away for these seven miles, thus forming a deep ravine which, if the present process continue without interference, will ultimately, after the lapse of thousands of years, extend back to Lake Erie. The gorge of Victoria Falls [58] is another example of the same action. The great majority of waterfalls are thus placed at the head of gorges which have been cut by falling water; but there is no definite distinction between a waterfall, a cascade, a rapid, a torrent, and an ordinary river. Such difference as exists is due merely to the greater or less degree of slope down which the river flows.

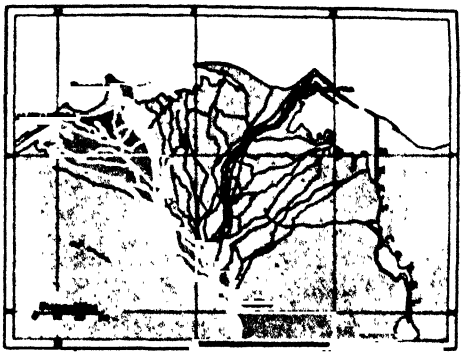
Pot-holes. A proof of the power of running water to abrade the rocks is afforded by the *pot-holes* [57], which are familiar objects in the bed of a rapid stream. These are large or small hemispherical basins which have been worked out by eddies whirling round stones and pebbles which drill out the rock. Very often, when the stream is low in summer, and these pot-holes are left empty, a heap of loose stones is found lying in them ready again to take up the work of abrasion when the stream comes down in flood and the water whirls them round and round, to scour the pot-holes larger. It is frequently by the gradual enlargement of such pot-holes, until they emerge into one another, that the river deepens its rocky gorge, just as a stealthy burglar cuts a panel out of a door by boring a series of closely adjoining holes with his centre-bit. But the tendency of the river is to wear down its course until its slope has become so gentle that it loses almost all its erosive power. It also tends to widen the valley through which it runs by altering its course from side to side. If it happen originally to run in a perfectly straight course, which is very unusual, but may take place where it has descended the line of some fault or fissure in the strata, it continues to run in that straight and narrow path; but it is much more common that it should form loops and bends, owing to the original inequalities of the slope and texture of the surface. When this is the case a river always tends to widen its course and exaggerate its bed, because its current bears with greater strength on the concave side of each bend; this side of the bend is worn away while the opposite side, where the water is comparatively still, is built up at the same time by the deposit of sediment [59]. It is in this way that great river valleys like those of the Thames and Mississippi have been constructed, and that the present river flows down in a winding stream between wide banks of alluvial soil which the river has brought down from higher portions of its course and there deposited.



59. DIAGRAM SHOWING ACTION OF RIVER

Rivers Transport Sediment. Rivers, indeed, are not only *destructors* but *constructors*. In addition to their erosive action in carving out their valleys, they have a constructive action in depositing *alluvial soil*, which is especially important to us because it happens to be particularly well adapted to the growth of vegetation. The ability of a river to transport sediment depends entirely upon the speed at which it flows. High up its course among the mountains, where it flows with torrential rapidity, it tears away sand and earth and stones from its banks and bed and carries them along down to the plains. But when it reaches a place where the slope is gentle, and the water consequently flows more slowly, it is no longer able to transport the materials which it has carried thus far, and it begins to drop them along its bed. A river always flows faster at the middle than at the sides, because of the friction caused by its banks, and it thus tends to deposit materials which it can carry no further along its sides, especially on the convex side of every bend [59], where the current is directed away towards the opposite bank.

River Terraces. As the course of the river wanders from side to side of its valley, it leaves behind it broad flats or terraces of alluvial soil, which are at first overflowed periodically when more water comes down in the rainy season than the actual watercourse is able to hold, but which are ultimately left permanently dry when the watercourse has been sufficiently deepened. In this way we get the typical river valley, with the river flowing along its winding course in the middle of the broad alluvial terraces rising on very gentle slopes up to the foot of the hills which bound the valley on both sides, and by their height mark the depth to which the river has cut it from the surrounding country.



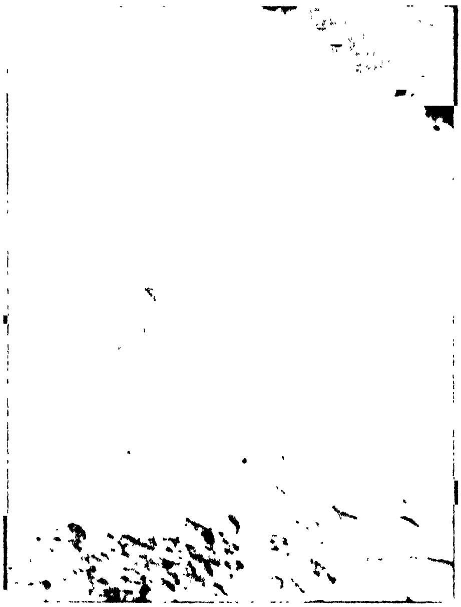
60. DELTA OF THE NILE

Deltas. The final end of a river is usually in a lake or sea. There are a few exceptions in countries where rivers end by being absorbed in sandy deserts. But the course of the river from the higher ground to the lower generally ends in some larger body of water. To this it transports such of the finer sediments as its gradually slackening stream is able to bring to the end of its journey. When the stream of the river enters the lake or sea it gradually slows down until it ultimately comes to rest, and, as it slows, it gradually drops its sediment to the bottom of the water. In this way vast deposits are produced by the larger rivers. It has been said with some truth that the whole of Lower Egypt is simply the accumulated sediment of the Nile, and that Holland has all been transported by the Rhine from the mountains of Switzerland.

Where a great river enters the sea it is constantly in the habit of building up new land, which is known as the *delta* [60], because its shape usually corresponds to the fourth letter of the Greek alphabet. The deltas of the Nile and Mississippi cover a great area of ground and project far out into the sea. They are constantly being added to by the great rivers which have built them

Valentine

61 BONDHUUS GLACIER, MAURANGER FJORD, HARDANGER, NORWAY, SHOWING ERRATIC BLOCKS



By permission of Miss Mary K. Andrews, Belfast

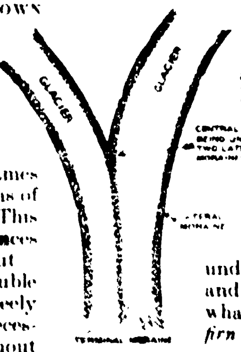
65. MORAINE CUT THROUGH BY BLOODY BRIDGE RIVER, NEAR NEWCASTLE, CO. DOWN

Why the Sea is Salt. Rivers not only carry sediment, which is *mechanically suspended* in their water in consequence of the speed at which they flow, but they also *dissolve* many substances, such as salt, various carbonates and sulphates. The Thames is estimated to bring half a million tons of mineral salts into the sea every year. This constant transport of dissolved substances into the sea has made it salt throughout, common salt being the most readily soluble of minerals, and therefore the most freely transported by rivers. It is thus a necessary consequence that all lakes without an outlet must eventually become salter and salter, since the amount of water in them is kept practically constant by evaporation, which does not affect mineral salts constantly poured into them. The Dead Sea, thus fed by the Jordan, and the Great Salt Lake of Utah, are well known examples. In this way, also, though much less appreciably than by mechanical transport, rivers are always at work removing solid matter from the land and wearing down its general level. In return as we shall see directly, it is largely to this same work that we owe the building up of new continents.

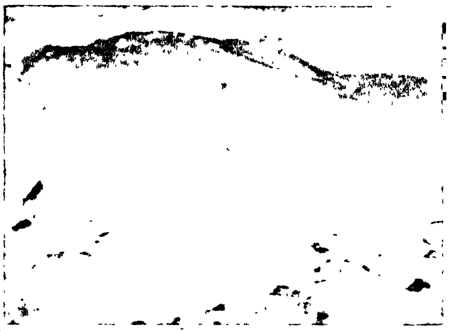
Glaciers. A *glacier* is similarly a river of ice which performs the work of erosion on the land in much the same way as an ordinary river, though there are well-marked differences which enable the geologist to distinguish the work of a glacier from that of running water. Water assumes the solid form of ice at a temperature of 32° F. In the regions bordering the North and South Poles the normal temperature at sea-level stands below this throughout a great part of the year, and consequently the land is permanently covered with an ice-sheet.

In temperate climates like our own it is only in the depth of winter that the temperature remains below the freezing point long enough for the ground to be covered with ice or snow. But among the hills the case is different. The higher we rise above the sea-level the lower does the temperature fall, and there is a definite level known as the *snow-line*, above which water normally exists in the form of snow or ice. This snow-line varies in height according to the district, being on the actual sea-level at the Poles, and as much as 18,000 or 19,000 ft. above the sea in the tropics. In the Alps the snow-line stands at 8,500 ft., and there is no hill in the British Islands which quite rises to it, though Ben Nevis comes very near.

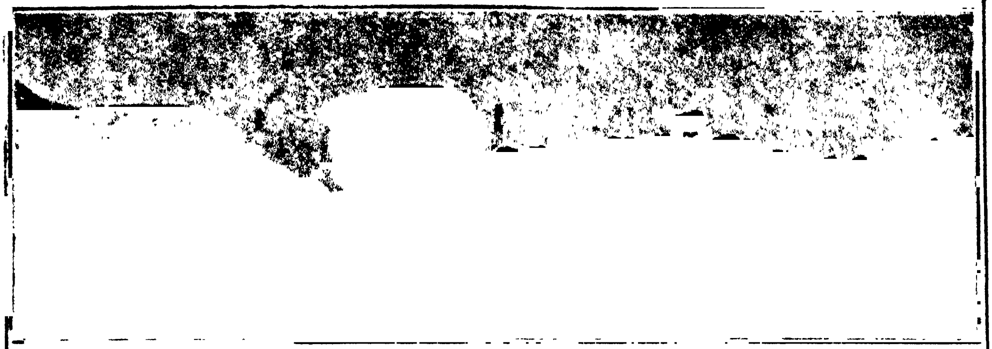
How Glaciers are Formed. In countries where the hills rise above the snow-line, water which falls from heaven—or, to put it more accurately, is condensed from the atmosphere—remains frozen throughout the year on the hills which are high enough. On the higher parts of such a mountain chain the *snow* is loose and soft, much as we find it on the ground after a winter snowfall. Lying as a rule upon a slope, it has a tendency to creep slowly downward by gravitation. If the slope be considerable, it often breaks loose and rushes down in huge masses, known as *avalanches*, which often cause great destruction, and have a marked erosive effect upon the rocks over which they pass. But when the snow only creeps slowly downward, and more snow is continually being deposited higher up, it slowly compacts itself under the pressure of the upper layers and passes first into the condition of what in Switzerland is called *névé*, or *firn*; later on its separate grains are squeezed together, and the whole mass passes into compact crystalline *ice*. It is in this way that glaciers, or ice-rivers, are formed. Like ordinary rivers, they



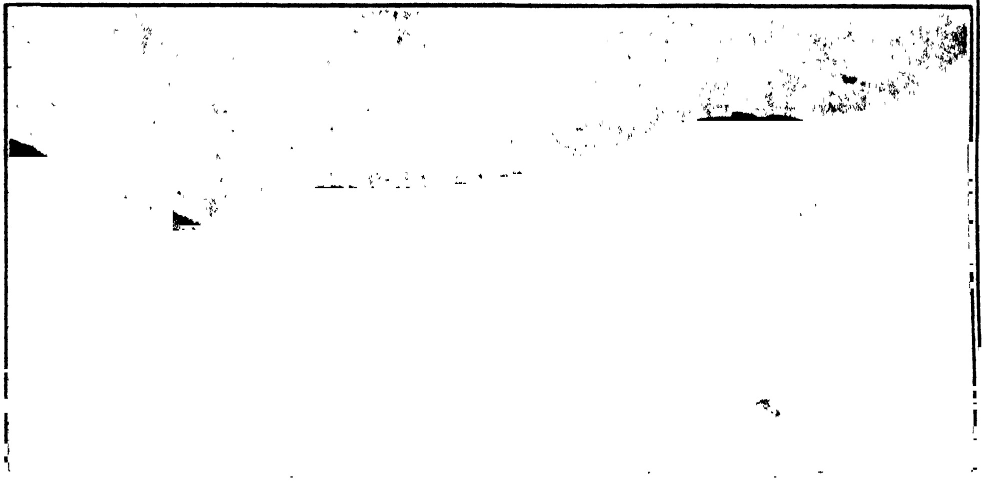
66. DIAGRAM OF GLACIER, SHOWING TYPICAL MORAINES



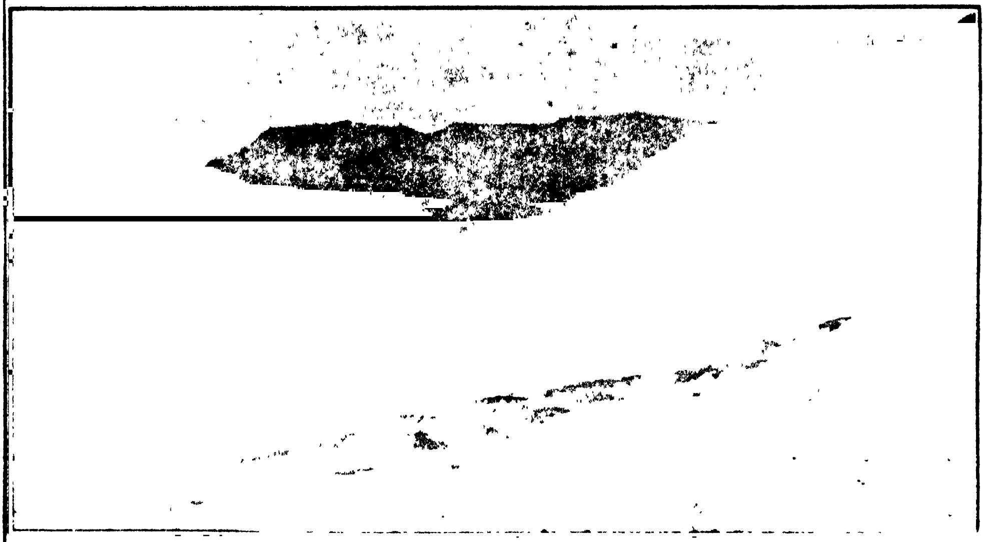
67. STRIATED BOULDER IN SITU, IN LOW CLIFF OF BOULDER CLAY, DIGANWY, CARNARVONSHIRE



62. PERCHED BLOCK, CWM IDWAL, N. WALES



63. ROCHE MOUTONNÉE, CWM IDWAL, N. WALES



64. VALE OF NANTFRANCON (LOOKING UP THE PASS)
Bed of an ancient

THE ACTION OF GLACIERS ON THE

seek the direction of greatest slope, gravitate thus to the gorges and valleys of the hills, and move steadily downward. We are accustomed to think of ice as a solid and rather brittle substance. But under the considerable pressure exerted by its own weight in great masses it is capable of flowing like water, although much more slowly and with far greater viscosity.

Glacier Motion. A glacier is continually in motion like a river, though its motion is so slow that it was only detected when science was called in to study Alpine phenomena. If a row of stakes be driven into the ice right across a glacier, in the course of a few days it will be found that the whole line has moved downwards in reference to fixed stakes on the rocky banks, and also that the line is no longer straight, but has developed a curve which is convex downward. In other words, the ice in the centre of the glacier moves faster than that of the edges, just as happens with the water of a river; and in both cases it is the friction of the banks which accounts for this. As a rule the motion of the ice is slow, being about 1 or 2 ft. a day in the Swiss glaciers, though in the glaciers of Greenland the rate of motion is sometimes as much as 50 or 100 ft. in the twenty-four hours. The ice adapts itself like a plastic fluid to the irregularities and curves of the bed in which it moves. It is constantly cracking into *crevasses*, which sometimes swallow up mountaineers, in consequence of the bending which it undergoes in moving downwards along an ordinary valley. These crevasses keep reuniting and changing in position. If the glacier comes to a precipice in its downward course it flows over in an *ice-fall* [61], which is all splinters and pinnacles, and corresponds to a waterfall in a river. The steady flow of ice is largely due to the phenomenon known as *regelation* [see PHYSICS], which consists in a constant momentary melting and refreezing of the ice, due to changes in pressure.

Glaciers Transport Rocks. As the glacier travels downward it does a great deal of geological work. It transports a large bulk of rocky fragments and detritus; it erodes the bed in which it travels; and ultimately it heaps up vast deposits of débris at its lower extremity. It will be obvious that the fragments of rock which frost and other agencies break off from the banks of the glacier bed fall upon the surface of the ice and share its motion downward towards the valley. They are naturally ranged along each side of the glacier, and there form two long beds of stones and fragments, which are known as *moraines* [65]. If two glaciers meet where their separate valleys converge, two of their *lateral* moraines coalesce, and are carried down the centre of the large glacier thus formed; this is known as a *central* moraine [66]. When the glacier travels down the valley below the snow-line it reaches a spot at which its ice melts away in the warmer air, and the glacier there ceases or gives birth to a river. It is at this spot that all the rocky fragments which have been brought down by the glacier are heaped up in a vast accumulation which is known as the *terminal* moraine [66]. The moraines of ancient glaciers are very common objects throughout the whole of Northern Europe, showing that at one time a vast accumulation of ice covered the whole of this region.

Glacial Erosion. A glacier is also a powerful agent of erosion. The ice in its downward movement rasps and grinds along its bed, and acts as a plough. Further, a great many of the stones which fall upon the surface of the glacier tumble into crevasses, and sink down to the bottom, where they are frozen into the lower part of the ice and dragged along, scratching and eroding the surface of the ground beneath. Consequently, the bed of an ancient glacier [64] is characterised by rocks which are polished and rounded, and at the same time considerably scratched, or *striated* [67], the scratches all running in the same direction—that in which the glacier formerly moved. They are caused by the fragments of rock which were frozen into the lower part of the glacier, and served as teeth to its powerful rasp. The underlying rocks are only superficially scratched, and present a generally rounded aspect because all their edges and angles were planed off by the powerful pressure of the ice-sheet, often hundreds of feet in thickness. From their resemblance in contour to the backs of sheep, such rocks [63] are frequently known as *roches moutonnées*, or *grey wethers*. Sometimes huge boulders, which may contain many tons of rock, fall upon the surface of a glacier, and are transported by it to positions far removed from that of the parent rock, and the existence of such *wandering*, or *erratic blocks* [62] is always the sure indication of the former existence of a glacier. Where the land has once been covered by a sheet of ice there is often left behind a characteristic deposit known as *till*, or *boulder clay*. This consists of a stiff clay, hardened from the fine mud which the glacier rubbed down under its enormous pressure, thickly filled with the larger or smaller rocky fragments or boulders which present the characteristic striation caused by glacial action. The whole of our islands was once covered by a vast sheet of ice, and all these various traces of glacial action are found scattered widely over them.

Continued

SHAPING OF ENGLISH PROSE

A Further Study of the Prose-writers,—from Roger Ascham to John Dryden,—together with Examples of their Styles

Continued from page [illegible]

By J. A. HAMMERTON

Roger Ascham. As our Anglo-Saxon forbears fought against the influences of Norman-French, so ROGER ASCHAM (b. 1515; d. 1568), the tutor of Queen Elizabeth, reflected the native English spirit in his strong masculine prose and his antagonism to the "Italianate Englishman," who modelled his conduct and his studies on what he or others brought back from Italy in those early days of Continental intercourse and travel. Ascham was devoted to the old English pastime of archery, and wrote a defence of it in English—"Toxophilus"—which he dedicated to Henry VIII., adding an address to the gentlemen and yeomen of England in which occurs a passage that forms at once an apology for and a defence of his native tongue: "As for the Latin or Greek tongue, everything is so excellently done in them that none can do better; in the English tongue, on the contrary, everything is in a manner so meanly, both for the matter and handling, that no man can do worse." Then follows the remark: "He that will write well in any tongue must follow this counsel of Aristotle, to speak as the common people do, to think as wise men do." There are several important works on education which belong to the sixteenth century, but Ascham's "Scholemaster" is the first in point of time, and contains not a little advice the value of which is of a permanent character. One of the truths that he urges is being propagated in our own day with all the energy of our twentieth century reformers: namely, the need of awakening in the mind of the pupil an interest in his work. In this connection the appended extract from the "Toxophilus" will be of interest to the reader:

The Wisdom of Ascham. "If men would go about matters which they should do and be fit for, and not such things which wilfully they desire, and yet be unfit for, verily greater matters in the commonwealth than shooting should be in better case than they be. . . . This perverse judgment of men hindereth nothing so much as learning, because commonly those that be unfitted for learning be chiefly set to learning. As if a man nowadays have two sons, the one impotent, weak, sickly, lisping, stuttering, and stammering, or having any mis-shape in his body, what does the father of such one commonly say? This boy is fit for nothing else but to set to learning and make a priest of. . . . Fathers in old time, among the noble Persians, might not do with their children as they thought good, but as the judgment of the commonwealth thought best. This fault of fathers bringeth many a blot with it, to the great deformity of the commonwealth. . . . This fault, and many such like, might be soon wiped away if fathers would bestow their children always on that thing whereunto nature hath ordained them most apt and fit. For if youth be grafted straight and not awry, the whole commonwealth will flourish thereafter."

Henry VIII., who encouraged Ascham, must have it placed to his credit also that he gave similar aid to SIR THOMAS ELYOT (b. about 1490; d. 1546), who wrote on behalf of good government, and translated Plutarch "On the Education of Children."

The Bible and English Literature. As poetry, in a chronological sense, takes precedence of prose in the history of English literature, so religious works precede secular in influencing the growth of English prose. We may not pause to consider this subject at any length; but the services of the early translators of the Bible cannot be overestimated. First among these translators was JOHN WYCLIFFE (b. 1325?; d. 1384). Here it is important to remember, however, that neither the "Wycliffe Bible" nor any of its successors was the work of one man, although "Wycliffe's Bible," "Tyndale's Bible" and "Coverdale's Bible" are common terms. According to Father Gasquet, "Wycliffe's Bible" was the work of the English bishops. This contention remains but a theory. Before Wycliffe's time only portions of the Scriptures had been translated into English. Wycliffe—to follow the accepted story—set himself a few years before his death, in 1384, to the task of producing the first complete English Bible. By 1382 he had completed the New Testament. His friend Nicholas, of Hereford, translated most of the Old Testament and the Apocrypha. John Purvey, a pupil of the Reformer, revised the work four years after Wycliffe's death. The translation (or paraphrase), which was made from the Vulgate (or Latin version), was originally issued in manuscript form; of this 150 copies are still extant. Written as it was for the common people, it is remarkable to find with how much ease "Wycliffe's Bible" can still be read. Wycliffe was a Yorkshireman, and we are told that when, a few years ago, several long passages were read to a congregation in his native county, not only were they understood by the hearers, but almost every word was found to be still in use.

William Tyndale. The work of Wycliffe was carried on and improved by WILLIAM TYNDALE (b. 1484?; d. 1536), a pupil of Erasmus, the great co-worker with Martin Luther in the Reformation. When Erasmus published his Latin version of the New Testament in 1516, he declared his wish that even the weakest woman should read the Gospels. "I long," he said, "that the husbandman should sing portions of them as he follows the plough, that the weaver should hum them to the tune of his shuttle, that the traveller should beguile with their stories the tedium of his journey." Tyndale declared: "If God spare me I will one day make the boy that drives the plough to know more of the Scriptures than the Pope of Rome." Tyndale, who was a good Greek scholar, studied Hebrew for the purpose in hand, and while consulting the Vulgate went back to the originals as the basis of his version. He was helped in his task by a fugitive friar named Roy and others. It was "Tyndale's Bible" which, revised by Miles Coverdale (b. 1488; d. 1568)—the first complete printed English Bible—and edited and re-edited as "Cromwell's Bible" (1539), and "Cranmer's Bible," or "The Great Bible" (1540), was set up in every parish church in England, in some cases being chained to the lecterns, or reading desks.

The Influence of the Bible. To quote Dr. Stopford Brooke, "It got north into Scotland and made the Lowland English more like the London English. It passed over to the Protestant settlements in Ireland." After its revision in 1611—there had been printed meanwhile the "Genevan Bible," a work handier in size than its predecessors, in Roman type and with the text divided into verses—it went as the Authorised Version with the Puritan Fathers to New England and fixed the standard of English in America. "Many millions of people now speak the English of Tyndale's Bible, and there is no book which has had, through the 'authorised' version, so great an influence on the style of English literature and the standard of English prose." In Edward VI's reign Thomas Cranmer (b. 1489; d. 1556) edited the English Prayer Book (1549-52). "Its English," Dr. Stopford Brooke notes, "is a good deal mixed with Latin words, and its style is sometimes weak or heavy, but on the whole it is a fine example of stately prose. It also steadied our speech." To tell the influence of the Bible on English writers from Shakespeare's time to Swinburne's would be to specify nearly all the best work of our greatest writers. Need we therefore urge its study upon our readers, when scarce any writer of note but has either acknowledged its inspiration or shown trace of it in his work? Too much stress cannot be laid upon the need—apart from all religious considerations—of Bible-reading on the lines laid down by Richard Moulton in that admirable work "The Literary Study of the Bible."

Theology and Philosophy. The development of English rhetoric and English philosophic thought between the close of the fifteenth and the earlier part of the eighteenth century may be studied in the writings of Hugh Latimer (b. 1485?; d. 1555), Bishop of Worcester, whose sermons well sustain the homely and direct character of his native tongue; John Knox (b. 1505; d. 1572), the Scottish reformer and historian; John Foxe (b. 1516; d. 1587), whose "Actes and Monuments," commonly known as "Foxe's Book of Martyrs," "gave to the people of all over England a book which, by its simple style, the ease of its story-telling, and its popular charm, made the very peasants who heard it read feel what is meant by literature"; John Jewel (b. 1522; d. 1571), Bishop of Salisbury, a learned Protestant controversialist; Richard Hooker (b. 1554?; d. 1600), author of "The Lawes of Ecclesiasticall Politie," a great theologian whose memory is enshrined in "Walton's Lives," and whose character is fitly indicated on his monument at Bishopsbourne, Kent, as "judicious"; William Chillingworth (b. 1602; d. 1644), a notable anti-Romanist; Joseph Hall (b. 1574; d. 1656), Bishop of Exeter and Norwich, one of the first of English satirists; Jeremy Taylor (b. 1613; d. 1667), Bishop of Down and Connor, the author of "Holy Living" and "Holy Dying," and a voluminous writer who, in the words of his friend Bishop Rust, of Dromore, "had the good humour of a gentleman, the eloquence of an orator, the fancy of a poet, the acuteness of a schoolman, the profoundness of a philosopher, the wisdom of a chancellor, the reason of an angel, and the piety of a saint"; Thomas Hobbes (b. 1588; d. 1679), a philosopher who applied the principles of geometry to the judgment of human conduct, and who, in his "Leviathan," "De Cive," "Human Nature," and other works, showed himself to be "the first of all our prose writers whose style may be said to be uniform and correct and adapted carefully to the subjects on which he wrote"; Thomas Fuller (b. 1608; d. 1661), the style of whose best-known work, "Worthies of England," shows admirable narrative faculty, "with a nervous brevity and point almost new to English, and a homely directness ever shrewd and never vulgar"; Sir Thomas Browne (b. 1605; d. 1682), a Norwich physician and author of "Religio Medici," than whom, according to Mr. Edmund Gosse, "among English prose writers of the highest merit there are few who have more consciously, more successfully, aimed at the translation of temperament by style," and who "unquestionably tasted the divine pleasure of writing for its own sake"; John Bunyan (b. 1628; d. 1688), author of "The Pilgrim's Progress," a work as famous as "Robinson Crusoe," as fascinating in a narrative sense, and of perennial influence on the religious thought of the young of all nations; Isaac Barrow (b. 1630; d. 1677), another eloquent preacher and controversialist (note especially his treatise on "The Pope's Supremacy"), and as a mathematician worthy to stand near his pupil Isaac Newton (b. 1642; d. 1727); Richard Baxter (b. 1615; d. 1691), whose life may be studied as an example of self-help by the side of Bunyan's, and the style of whose many writings "is one of the finest specimens of direct masculine English, and a model for all who wish to talk to people instead of at them"; John Tillotson (b. 1630; d. 1694), perhaps the only primate who took first rank in his day as a preacher, but who "probably presents more examples than any other author of passages wherewith to exercise the skill of the student of English composition in weeding out their superfluous words and phrases" ; John Locke (b. 1632 ; d. 1704), author of "Two Treatises of Government," "An Essay concerning Toleration," "An Essay Concerning Human Understanding," a work especially to be commended to students on "The Conduct of the Understanding," and a philosopher who is spoken of as "the unquestioned founder of the analytic philosophy of mind" ; and Gilbert Burnet (b. 1643 ; d. 1715), Bishop of Salisbury, and author of a "History of the Reformation" and a "History of My Own Times."

Regarded in this brief summary, the works of these theological writers may appear uninviting ; but the general reader no less than the student cannot neglect them all without missing a fruitful part of the great and rich field of our national literature. Foxe's "Book of Martyrs," Taylor's "Holy Living" and "Holy Dying," Hobbes's "Leviathan," Fuller's "Worthies," Browne's "Religio Medici," Bunyan's "Pilgrim's Progress" and "The Holy War," Locke's "Human Understanding" these especially, and others that we have named, are works of which every one who aspires to a sound appreciation of our literature should have first-hand knowledge ; and just as we in early youth read Bunyan for the sheer pleasure of his narrative, so in manhood we may read the other religious and philosophical writers for their charm of style, their wisdom and humanity.

Prose of the Poets and Historians. Both Spenser and Shakespeare wrote prose. Spenser's "View of the Present State of Ireland" is written in a most pleasing style. Shakespeare's prose has been the theme of many commentators ; see, for example, the admirable little manual of the late George L. Craik. The student is recommended to study the "men in buckram" section of "Henry IV." The "Arcadia" and the "Defense of Poesie" of Sir Philip Sidney (b. 1554 ; d. 1586) are also to be studied in this connection. The first popular English history in the language is "The History of England to the Time of Edward III." of the poet Samuel Daniel (b. 1562 ; d. 1619). After Daniel's work may be considered the "History of the World," written in the Tower by Sir Walter Raleigh (b. 1552 ; d. 1618), and to be read for its human and personal interest more than on account of its intrinsic value as history. Edward Hyde, first Earl of Clarendon (b. 1609 ; d. 1674), friend of poets like Jonson and Waller, wrote a "History of the Rebellion." This was modelled on the style of the Roman historian Tacitus, and is specially notable for its biographical value. The "Life of Colonel Hutchinson," the Puritan, by his widow, Lucy Hutchinson (b. 1620), is one of the most delightful of biographies with a historical character for subject, and taken up as a study will be read through for the charm and simplicity of the narrative. To the domain of history and antiquarian study belong the writings of William Camden (b. 1551 ; d. 1623), John Selden (b. 1584 ; d. 1654), John Stow (b. 1525? ; d. 1605), Raphael Holinshed (b. about 1580), and William Harrison (b. 1534 ; d. 1593). Mention must also be made here of the invaluable Diaries of Samuel Pepys (b. 1633 ; d. 1703) and John Evelyn (b. 1620 ; d. 1706), and the Letters and other writings of James Howell (b. 1594 ; d. 1666), and the exquisite epistles of Dorothy Osborne (b. 1627 ; d. 1695), afterwards the wife of Sir William Temple (b. 1628; d. 1699), diplomatist and essayist.

The Beginning of the Essay. The meaning of the word essay is "a testing." As we understand it to-day, an essay is a valuation of a subject, usually of a literary or social nature, from the standpoint of the writer. The "Essays of Montaigne," the translation of which by John Florio (b. 1553 ; d. 1625) preserves for us a vigorous and perennially delightful example of Elizabethan prose, hardly come within the limits of the essay as we understand the word. Shakespeare was evidently familiar with his Florio as he knew the translation of Plutarch's "Lives" by Sir Thomas North (b. 1535 ; d. 1601). The Elizabethan and Jacobean pamphlets were, in a sense, essays, but we see in them perhaps more distinctly the beginning of the modern newspaper, because they were published for controversial purposes. They form in themselves a somewhat absorbing branch of literary and historical study. A number of the writers of these pamphlets also wrote tales, so that while the "Euphues" of Lyly [see Literature, page 679] is generally regarded as the earliest English novel, it is not quite isolated as an example of English prose narrative. Even if we leave Sidney's "Arcadia" out of the question, there are the tales as well as the pamphlets of Robert Greene [see page 679] ; Thomas Lodge (b. 1558 ; d. 1625), whose "Rosalynde" inspired Shakespeare's "As you Like It" ; and Thomas Nash (b. 1567 ; d. 1601), whose "Jack Wilton" provided the prototype of Falstaff. Londoners who desire to learn how their predecessors lived three centuries ago will find a world of entertainment in "The Gull's Hornbook" of Thomas Dekker (b. 1570 ; d. 1637?). The more permanently interesting of all the pamphlets is the "Areopagitica," a trenchant plea for the liberty of the printing press, by John Milton (b. 1608 ; d. 1674).

The First English Essayist. The first of the English essayists is Francis Bacon (b. 1560 ; d. 1626). The student can have no better guide than is provided in the fiftieth of Bacon's "Essays"—the one entitled "Of Studies." We quote part of this as exemplifying Bacon's method and perspicuity of style :

"Studies serve for Delight, for Ornament, and for Ability. Their Chiefe Use for Delight, is in Privatenesse and Retiring ; For Ornament, is in Discourse ; And for Ability is in the Iudgement and Disposition of Businesse. For Expert Men can Execute, and perhaps Iudge of particulars, one by one. But the generall Counsels, and the Plots, and Marshalling of Affaires, come best from those that are *Learned*. To spend too much Time in *Studies*, is Sloth ; To use them too much for Ornament, is Affectation ; to make Iudgement wholly by their Rules is the Humour of a Scholler. They perfect Nature, and are perfected by Experience: For Naturall Abilities, are like Naturall Plants, that need Proyning by *Study*: And *Studies* themselves, doe give forth Directions too much at Large, except they be bounded in by experience. . . . Reade not to Contradict, and Confute; Nor to Beleeve and Take for granted; Nor to find Talke and Discourse; But to weigh and Consider. Some Bookes are to be Tasted, others to be Swallowed, and Some Few to be Chewed and Digested. That is, some *Bookes* are to be read onely in Parts; Others to be read but not Curiously; And some Few to be read wholly, and with Diligence and Attention. . . . Reading maketh a Full Man; Conference a Ready Man; and Writing an Exact Man. . . . *Histories* make Men Wise; *Poets* Witty; *The Mathematiks* Subtill; *Naturell Philosophy* deepe; *Morall* Grave; *Logick* and *Rhetorick* Able to Contend."

The Prose of Ben Jonson. Of Bacon's Essays Hallam rightly declared that it "would be derogatory to any educated man to be unacquainted with them." Next to them we should place the "Discoveries" of Ben Jonson [see Literature, pages 845-6], which Mr. Swinburne prefers before Bacon's Essays and Mr. Saintsbury describes as coming "in character as in time midway between Hooker and Dryden." Jonson's "Discoveries" have been too long neglected. A recent writer acutely says: "A comparison of the vocabulary of Sir Philip Sidney's 'Defense of Poesie' with that of the 'Discoveries,' written nearly sixty years later, will disclose a far larger number of words demanding explanation in the latter. On the other hand, a like comparison between the two works with reference to the structure of sentence and paragraph will exhibit a form and symmetry, a sense of order and proportion, and a consciousness of the demands of literary presentment in the 'Discoveries' for which we may look in vain in the somewhat loosely-strung periods and formless paragraphs of the 'Defense.' This contrast, as Prof. Schelling, the first adequately to edit the 'Discoveries,' points out, becomes the more startling when we remember that Sidney's work is characterised by a logical sequence and continuity of thought, and that Jonson's is more or less of a commonplace book containing, as he himself says, 'discoveries' made upon men and matter, as they flowed out of his daily readings, or had their reflux to his peculiar notions of the times." Here is a brief extract from Jonson's tribute to the eloquence of Bacon. It is largely an adaptation from Seneca on an Augustan orator:

Ben Jonson's Praise of Bacon. "There happened in my time one noble speaker who was full of gravity in his speaking; his language, where he could spare or pass by a jest, was nobly censorious. No man ever spoke more neatly, more presly (concisely), more weightily, or suffered less emptiness, less idleness, in what he uttered. No member of his speech but consisted of his own graces. His hearers could not cough or look aside from him, without loss. He commanded where he spoke, and had his judges angry and pleased at his devotion (disposal). No man had their affections more in his power. The fear of every man that heard him was lest he should make an end."

Lowell has applied this passage to Emerson. There is a great deal in Jonson's "Discoveries" concerning education and study that will generously reward the most careful attention. After Jonson, considered as an essayist, come Abraham Cowley (b. 1618; d. 1667), whose language is at once simple and graceful, and Sir William Temple (b. 1628; d. 1699), distinctly a predecessor of Addison.

It is difficult to classify the "Anatomy of Melancholy" of Robert Burton (b. 1577; d. 1640), but Johnson greatly admired it, and it is full of quaint and curious learning. The "Microcosmographie" of John Earle, Bishop of Salisbury (b. 1601; d. 1665), is at once of social and philosophical value, but stands, like the "Anatomy," by itself. Three other books that demand notice are the "Lives" and "Compleat Angler" of Izaak Walton (b. 1593; d. 1683), the first a gem of literary biography, the second one of the first of "country books"; and the "Autobiography" of Lord Herbert of Cherbury (b. 1581; d. 1648), which Mr. Swinburne has placed among "the hundred best books."

Criticism. The place of honour as the first of English critics belongs to John Dryden [see Literature, pages 992-3]. In the words of Lowell, Dryden, more than any other single writer, contributed, as well by precept as example, to free English prose from "the cloister of pedantry" and to give it "suppleness of movement and the easier air of the modern world." The introductions to Dryden's works are specially worthy of study. The famous "Essay on Dramatic Poesy" has already been commended. Nearly the whole of Dryden's criticisms will be found edited by Prof. W. P. Ker in his "Essays of John Dryden" (2 vols. Henry Frowde. 10s. 6d.).

Books to Study. In addition to the books specially mentioned in the text, we would commend "English Literature from A.D. 670 to A.D. 1832," by Stopford A. Brooke (Macmillan. 3s. 6d.); "History of the English Language," by O. F. Emerson (Macmillan. 6s.); "A Book of English Prose, 1387-1649," by W. E. Henley and C. Whibley (Methuen. 2s. 6d. net); and the "English Prose Selections," selected with critical introductions by various writers, and edited by Sir Henry Craik (5 vols. Macmillan. 7s. 6d. and 8s. 6d. per vol.). The last-mentioned work should be available in any good public library. Another useful work is that entitled "The Prose and Prose Writers of Britain," by Robert Demaus, M.A. (A. and C. Black). This was published in 1860, but copies are still seen on the secondhand bookstalls. Consult the catalogues of Messrs. Bell, Blackie, Cassell, Dent, Frowde, Harmsworth Library, Routledge, and others for cheap reprints of particular works.

Continued

USES OF REINFORCED CONCRETE

Various Systems of Construction Employed. Comparison with Other Structural Systems. Advantages. Practical Prohibition in London

By Professor HENRY ROBINSON

Reinforced Concrete Columns. Until recently reinforced concrete could not be economically employed for columns, as the compressive stresses were taken by the concrete alone, the safe limit of which varied between 500 and 600 lb. per square inch. By a new invention of Mr. A. Considère, the French engineer, the patent rights of which are held by the Armoured Concrete Construction Company, it is claimed that the safe limit for compression may be raised from 500 to 2,500 lb. per square inch. This invention consists of reinforcing the concrete by metal spirals or "hoops," made by winding a metal bar round a drum or roller. The pitch of the rings of the spiral vary according to the diameter of the bar used, but is generally between 1½ in. to 3 in. Down the interior of the spiral are placed either four or six longitudinal bars bound at intervals to the spiral. These bars are employed to prevent bulging when the column is under compression. Fig. 18 shows the manner of reinforcing a column by this method. This column, it is stated, will carry a load of 90 tons, with a factor of safety of 5.

Piles constructed by this system have been employed for foundations on the banks of the River Seine. Fig. 19 shows the form of piles used. They were 17 ft. long, driven by a 1·2 ton "monkey," with a drop of over 5 ft. The head of the pile was not, as with other systems, necessarily protected by a special cap, and only about 6 in. of the head of the pile, after being driven, had to be repaired.

The bridge at Plougastel is constructed of "armocrete," and the reinforcement is spiral or hooped. The bridge consists of two spans of 316 ft. 9 in., two of 106 ft. 7 in., and one of 52 ft. 3 in., making a total length of 895 feet.

Comparison with a Steel Joist. In comparing a beam constructed of reinforced concrete on the Hennebique system with a rolled joist [**20**], the steel rods which are placed in the lower part of the beam represent the line of tension and are acting similarly to the lower flange of a rolled joist. Concrete is the material which is relied on to resist the compressive stress in the upper part of the beam, and the connection between the flanges as formed by the web (still comparing the beam to a rolled joist) is also formed of concrete, which, in addition, encases the tension bars and protects them against external agencies. Fig. 22 shows the form of the hoop-iron stirrups, which are distributed along the whole length of the beam, being embedded in the core of concrete, connecting the upper and lower parts of the beam, thus making a solid and compact girder.

Tension Bars. The tension bars are of two kinds—*viz.*, straight bars parallel to the lower face of the beam, and bent or cranked bars placed over them, but in the same vertical plane.

The bent bars, taken in connection with the straight bars, and the stirrups (the latter being placed closer together at the ends of the beam), constitute an indeformable triangle, and the resistance afforded to shearing stress thus increases near the supports—*i.e.*, where the stress reaches its maximum.

A beam so formed is very similar to a timber beam trussed with iron tie-rods and brackets. Figs. 21 and 25 show the arrangement of a continuous Hennebique beam.

Fig. 25 shows the respective positions of the bars and stirrups, and how any bending stresses of the lower bars becomes transmitted by the stirrups to the upper part of the beam, and transformed and distributed in the way of compressive stresses in the mass of the concrete. Fig. 26 shows a cross-section taken through the beam.

An Armoured Concrete Floor. In order to divide up the component parts of a floor of any area that is supported by ferro-concrete beams, 24 shows the main beam constructed to receive the heaviest loads. Then comes the secondary beam, which is connected up to the main beam, and in turn receives a flat beam, which constitutes the floor. They are formed in a precisely similar manner to the other beams and are calculated to support the required load.

In constructing an armoured concrete floor, the practice hitherto has been to erect, in the first instance, a complete wooden floor extending over the whole area proposed to be covered, and, after covering the floor with a thin layer of concrete, to lay down the steel rods on it, and then to complete the floor with the necessary thickness of concrete over the steel rods. This mode of construction necessitates the use of a large quantity of timber, which cannot be removed until after the concrete has set. The practical objections to it are the cost of the timber, the delay in its erection and removal, the hindrance to the rapid completion of the armoured concrete floor, and to its increased cost.

Armocrete Tubular Flooring. A system employed by the Armoured Concrete Construction Company, of Westminster, does away with these drawbacks by dividing the structure into three different parts—namely, the so-called webs (A), the tubes (B), and the concrete floor on top (C), as shown in 23. The webs are made of concrete varying from 6 to 10 in. in depth, and in lengths up to 25 ft. They are reinforced with flat iron bars, *a*, *a*, the thickness of the top layer C, and the sectional area of the armouring inserted in the webs being according to the load the floors have to carry. The tubes are made in 9 in. lengths of earthenware, stoneware, or concrete composed of coke-breeze, or similar light material, and Portland cement.

When constructing a floor by this method, the workmen first place the webs in their proper positions (9 in. centres) without the help of any timbering, and the tubes are then put in. A floor is thus obtained. It is capable of carrying the weight of the workmen and materials stored on it. As soon as a certain area has thus been laid, a gang starts laying down the concrete (*c*) for the completion of the floor, the thickness varying from ½ in. to 3 in., according to the load to be carried. The reinforcement of the webs takes up the tensile stress, while the top part of the webs, together with the concrete flooring, take up the compressive stress. The surface underneath may be plastered or left rough, according to requirements. The webs are manufactured in workshops as near the site as possible, and can be handled by two or three men, according to their length and weight.

The hollow tubes form a good insulation against change of temperature, and can be utilised as conduits for electric wires or for water or steam pipes for heating purposes. The deadweight of such floors is considerably less than many other forms of reinforced concrete floors.

Practical Prohibition in London. The increasing demand for cheap and rapid construction, especially for buildings, opens out a wide field for the employment of reinforced concrete. The present Building Acts, and also the Local Government Board Regulations, make it difficult to employ this form of construction economically.

Although the advantages of reinforced concrete are now well recognised, it appears that the London County Council actually prohibit its use. A Paper was read at the Royal Institute of British Architects, in 1905, by Mr. Mouchel, of the Hennibique Company, in which the following passages occur:

"At the present moment London enjoys the unique privilege of being the only city in the civilised world where ferro-concrete constructions are actually prohibited.

"Foreign countries have their regulations, and generally they are not framed for the use of ferro-concrete, but notwithstanding these existing laws, after intelligent and impartial investigation of the various authorities, we have been permitted to construct everywhere.

"The London County Council do not tell us in so many words 'You shall not build.' They say the Act requires the external walls to be built in concrete of a certain maximum thickness, and if you comply with that condition you can build. To this we reply that our walls are not concrete; they are ferro-concrete, which is quite a different material, and to give them the thickness of common concrete would be, financially speaking, an impossibility. It would also be an absurdity, since our, comparatively speaking, thin walls are many times stronger and safer than those mentioned in the Act."

This state of affairs deserves attention and alteration. Special regulations and Acts have been made, both on the Continent and in America, which govern the use of reinforced concrete, and very properly require the employment of the best materials and the supervision of the work by skilled foremen.

The Hennebique system of reinforcing concrete has, however, been employed in London in places over which the London County Council have no jurisdiction, notably at the Victoria and the Albert Docks, where granaries and warehouses have been constructed.

Essential Conditions. Even without State regulations, these conditions must be strictly observed, otherwise failure will result.

The quality of the materials to be used must be absolutely the best. The concrete must be made with Portland cement, and not inferior cement or lime.

For watertight walls, tanks, conduits, pipes, etc., or similar work, the concrete must be made with sand and cement only, to assure impermeability, but where thickness is required as well as impermeability, the facework can be made with rich mortar and a backing of concrete, not quite so richly gauged as the mortar. When pipes constructed of reinforced concrete are expected to stand high pressures, a lining of metal is used to prevent leakage. This, however, increases the cost of construction, making it sometimes more economical to employ ordinary steel or iron pipes.

It is necessary to see that the concrete is well rammed round the metal, so that no voids exist. Where large sections of metal are employed, it is advisable to paint all metal work with cement grout before it is embedded, as by so doing the mass is made homogeneous—the metal being well cleaned previously. Another, and perhaps the best, reason for painting the metal before it is bedded is that, from experiments lasting over a number of years, it has been found that the surface of the metal is, by chemical action, covered with a coating of silicate of iron. This coating prevents rusting after the metal is embedded, and it has been found that rust existing previous to the embedding of the metal has been removed. This is of great importance, as at one time some doubt existed as to the life of reinforced concrete structures, especially those partially or wholly submerged.

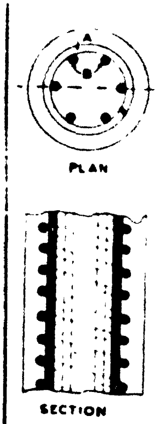
The Field of Reinforced Concrete. Reinforced concrete can be economically employed on bridges, buildings, floors, tanks, etc., etc., the cost of the work being lowered, while there is no loss of stability. It is essential that reinforced concrete must be designed, as well as carried out, scientifically, and, as before stated, only the best materials must be employed. Unscientific reinforcement produces waste of material, and may cause disastrous results. It is, therefore, necessary to look minutely into every detail of construction.

Advantages of Reinforced Concrete. There are many advantages in the use of reinforced concrete. Perhaps the greatest one is that of economy in cost and rapidity in construction. By employing this system, large masses of concrete or masonry can be saved, without loss of stability, and the cost of maintenance is practically nil. Mouldings for bridges or buildings can be made without false work of any kind, and are often made on the ground, being placed in position as the work proceeds.

Lintels, sills, mullions, and other small framings are generally moulded prior to their being fixed in position, the rods being tied together with wire distance pieces.

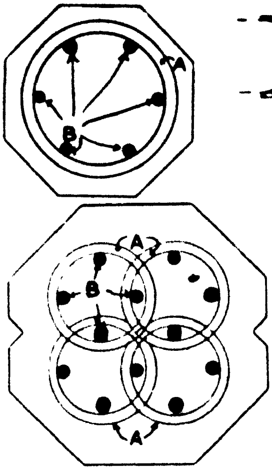
Structures of reinforced concrete are heavier for supporting the same load than those where iron or steel only is used. The hygienic value of structures made with reinforced concrete is indisputable, for they can easily be cleaned and disinfected, and do not harbour microbes. The fire-resisting properties of reinforced concrete have been proved beyond doubt, the low conductivity of the concrete protecting the metal from heating unduly. Buildings have been found to be as strong after a fierce fire as before, practically the only repairs necessary being to fittings. The finer the mesh of the reinforcing metal in the floors, etc., etc., the less the liability of the concrete to crack. Ordinary concrete rapidly disintegrates when subjected to sudden cooling, as when water is thrown upon it in times of fire. No such disintegration occurs with properly reinforced concrete. This is due to the coefficients of expansion of concrete and iron being practically the same, and therefore no internal stresses are set up by the differences of expansion or contraction.

Another great advantage of reinforced concrete is that it is free from decay due to damp, or the attacks of marine or other insects which cause so much damage to timber structures.



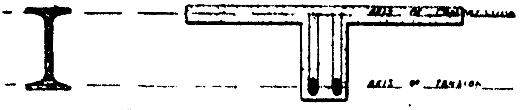
18. ARMOCRETE COLUMN

A ⅜ in. Metal spiral
B ⅝ in. Vertical bars



19. ARMOCRETE PILES

A Metal spirals B Vertical bars



20 FERRO-CONCRETE BEAM

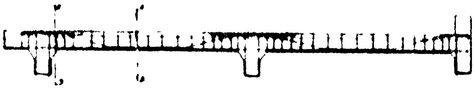
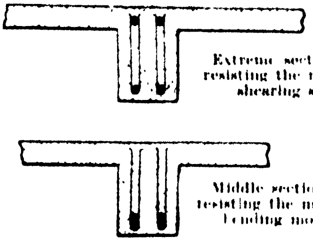


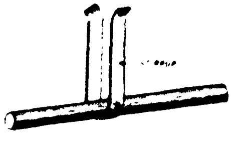
Diagram section through beam.



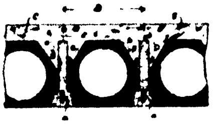
Extreme section E D resisting the maximum shearing stress

Middle section A B resisting the maximum bending moment

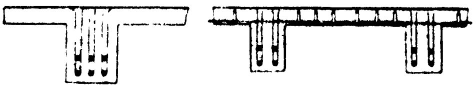
21. HENNEBIQUE'S SYSTEM



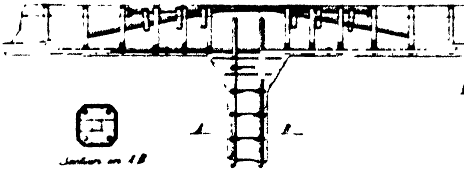
22 METAL STIRRUP



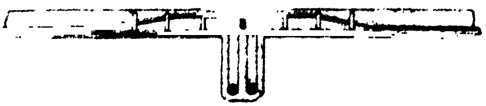
23 ARMOCRETE TUBULAR FLOORING



24. SECTION OF BEAMS - HENNEBIQUE'S SYSTEM



25 HENNEBIQUE'S SYSTEM
Junction of two beams and pillar



26. HENNEBIQUE'S SYSTEM.
Cross section through beam

Resistance to Vibration. The resistance to shocks and vibrations is very marked, as will be seen from the following experiments:

A weight of 112 lb. dropped 6 ft. 6 in. on an iron and brick floor produced vibrations $\frac{5}{16}$ in. in amplitude, lasting two seconds, while a weight 220 lb. dropped 13 ft. on a reinforced concrete floor produced vibrations $\frac{1}{16}$ in., lasting [illegible] second. When floors are to stand shocks or vibrations it is necessary to increase the richness of the concrete.

Tanks constructed of reinforced concrete withstand the action of alkalies better than when constructed of timber, but free carbonic acid, nitric, and hydrochloric acids have bad effects on the concrete. In cases where the solutions are weak, an increase of richness of the concrete overcomes this difficulty, but where strong acids are prevalent, reinforced concrete pipes, etc., should not be used. Hot fluids should never be turned into pipes made with reinforced concrete.

Influence of Atmospheric Action. Atmospheric action on reinforced concrete, such as humidity, causes elongation, while excessive dryness causes contraction. This action is more noticeable where the concrete has been made rich in cement. There is consequently a disadvantage in the employment of reinforced concrete in certain climates, applying more especially to exposed structures than to buildings or similar works. Timber expansion strips have been successfully used for retaining walls, but they cannot be employed for watertight work. Large arches and small bridges have been constructed with hinges on the abutments to overcome this difficulty.

The high percentage of dead to live load prevents the employment of reinforced concrete for bridges of very large spans.

The greatest care must be taken when removing centring, struts, props, etc., etc., from the work after its completion. It is best to leave all shuttering, centres, etc., etc., in position for several days, to allow the concrete to set thoroughly. The whole structure should remain for some weeks before any tests are applied to it. This period of rest is generally taken to be not less than four weeks, but it depends on the nature of the structure.

Estimating the Reinforcement. In determining the amount of metal necessary for reinforcing any particular structure, note must be taken of the quantity of cement to be employed in the concrete. The metal should have sufficient sectional area to sustain all the tensile stresses, but it should be observed that these stresses must not exceed the coefficient of elasticity of the concrete, or cracking will occur. The position of the bars is found from the fact that the value is in direct proportion to their distance from their neutral axis. The safe tensile stress for iron bars varies between 6 and 7 tons per square inch.

The modulus of elasticity of steel may be taken as between 30,000,000 and 36,000,000 lb. per square inch, and that of concrete from 1,000,000 to 4,000,000 lb. per square inch, according to the amount of cement in the mixture. Another important factor is the amount of water used in mixing the concrete, as, should it be used too freely, a loss of elasticity occurs. It is necessary to have sufficient water for hydrating the cement, and for ordinary cement it may be taken that the best results are obtained by adding 4 to 4½ gallons of water to each cubic foot of cement used. It has been found that it is better to use the concrete fairly dry, and to ram it well into position round the metal.

Tensile Resistance. The resistance of concrete to tensile stresses is taken to be from one-tenth to one-twelfth that of its resistance to compression. In America the compressive stress for concrete is taken to be 500 lb. per square inch, while in Prussia it varies from 285 to 500 lb. per square inch, according to gauging.

The following table gives some of the results arrived at by Professor Hatt when experimenting with cement mortar gauged 3 to 1:

Time after Moulding.	Strength in lb. per Square Inch.		Ratio of Compressive to Tensile Strength.
	Compressive.	Tensile.	
7 days ..	3,145	412	7·65
28 days ..	5,860	505	11·60
3 months ..	8,005	626	12·78

From experiments carried out by Mr. Baker, and tabulated in his book, "Masonry Construction," the compressive strength of concrete is found to vary almost directly as the strength to which it has been gauged. The following table shows the crushing strength taken 600 days after moulding:

Proportion of the Mortar used with the same Stone.		Proportion of Cement Relative.	Crushing Strength.
Cement.	Sand.		
1	1	1·00	5,000
1	2	0·67	2,300
1	3	0·56	2,500
1	4	0·40	2,000
1	5	0·33	1,600

Dr. R. Dykerhoff carried out some experiments on concrete cubes 28 days after moulding. The results are tabulated below:

Proportions.			Crushing Strength in lb. per Square Inch.
Portland Cement.	Sand.	Stone.	
1	2	0	2,158
1	2	3	2,783
1	2	5	2,414
1	3	0	1,406
1	3	5	1,661
1	3	6½	1,534
1	4	0	1,068
1	4	5	1,291
1	4	6½	1,221

It will be seen that concrete composed of cement, sand, and stone, or shingle, is always stronger than that composed only of cement and sand. By comparing these tables, it will be noticed that the strength of the concrete increases with its age.

Compression Limit. In reinforced concrete structures the safe limit for compression may be taken as 1,450 lb. per square inch. This is the mean value after six weeks from moulding, and by allowing a further factor of safety of 3·5, the compressive resistance becomes 415 lb. per square inch. This figure is low when it is considered that experiments on large pieces show a resistance as high as 2,510 to 3,490 lb. per square inch at failure. Taking a safe limit at two-thirds of the final resistance, and allowing for the factor of safety 3·5, we get as safe stresses 665 lb. per square inch.

Taking everything into consideration, it is advisable to adopt 400 lb. per square inch for pieces in direct compression and reinforced with longitudinal bars tied with cross-pieces, and 500 lb. per square inch where pieces are to be subjected to bending. Where vibration is anticipated the figure is sometimes taken as 360 lb. per square inch. It must be borne in mind that special cases require to be skilfully dealt with by the designer.

The resistance of concrete to shearing is taken as one-eighth of its resistance to compression—that is, about 50 lb. per square inch.

In calculating the tensile stresses to be taken by a reinforced concrete structure, the value of the resistance of the concrete is at present neglected. This is on the safe side, but when the behaviour and properties of reinforced concrete are better known, the tensile assistance due to the concrete may be taken into consideration.

Fire-resisting Properties. The fire-resisting advantages of reinforced concrete must not be relied on unless certain conditions are observed, the neglect of which involves serious consequences. The main points for attention are the proper protection of the metal work by embedding all rods, etc., in suitable aggregate, and in making the aggregate of materials which are fire-resisting. The subject has received attention from the Fire Offices' Committee, who have issued rules defining the essentials to be observed to bring buildings constructed on this system within the insurance lines. The rules refer to embedded metal rods or bars spaced not more than 12 in. apart and overlapping at least 6 in. at all abutments and intersections, and having bands or bars across the concrete, and specify that walls and partitions must be of brick, terra-cotta and cement concrete composed of broken brick, burnt ballast, furnace clinker, or similar hard or burnt material; that the concrete is to be composed of sand and gravel which will pass through a ¾ in. mesh, or of the afore mentioned materials. It is also provided that the cement used should be Portland (equal to the British Standard Specification of December, 1904), in the proportion of 6 cwt. of cement to each cubic yard of concrete, and that the concrete must be thoroughly mixed, both dry and wet, and must be rammed round the metal work in position. Every part of the metal work must be closely encased in solid concrete. The rules require the external walls to be not less than 6 in., and party walls not less than 13 in. thick; that floors must be constructed of reinforced concrete not less than 5 in. thick in any part (no woodwork to be embedded therein), supported on beams or columns of similar reinforced concrete.

Reinforced Concrete Roofs. Roofs, if constructed of reinforced concrete, may be dealt with as floors, but in no part shall the concrete be less than 3 in. thick. It is required that all metal work must be embedded in solid concrete, so that no part of any rod or bar shall be nearer the face of the concrete than double its diameter. Such thickness of concrete must, in no case, be less than 1 in., but need not be more than 2 in.

These rules, and others which have not been referred to, afford a basis for any legislation, or bylaws, which may be necessary to enable the advantages of this most important system to be utilised without the risks which would result from its employment by unskilful or ignorant persons. Several cases are known where unsatisfactory results have attended the unskilful use of reinforced concrete. One occurred in Madrid, in June, 1905, when the columns supporting the roof of a covered reservoir in course of construction gave way. The roof consisted of arches of reinforced concrete of 4 in. total thickness and 19 ft. span with a rise of one-tenth the span. These arches took their springing from girders of reinforced concrete, each of which extended in a continuous length over two compartments, and thus measured 580 ft. in total length. The depth of the girders was 20 in., and the width of the top was 10 in., being less at the bottom. These girders were supported on ferro-concrete columns 10 in. square and 27 ft. 6 in. long without any bracing. Owing to the changes of temperature which occurred, and their effect upon the long girders, together with the absence of bracing to the columns, distortions took place which resulted in complete failure.

Reinforced Concrete concluded

Continued from page 182

SEEING NORTH AMERICA

A Concise Guide to the Chief Centres of Historical, Picturesque, and Industrial Interest in British North America and the United States

By J. A. HAMMERTON and WILLIAM DURBAN, B.A.

HAVING, in the preceding sections of this course in educational travel given a complete guide to all the leading features of interest on the Continent of Europe, we now conclude our series of outline tours with Canada and the United States. It was clearly impossible to treat the whole globe in the manner in which we have dealt with Europe, and we have had to choose between suggesting tours in Egypt, Palestine, India, South Africa, or any of those other quarters of the earth which teem with interest to the studious traveller, and confining ourselves to North America. In Canada and the United States the advance of industry makes these countries of paramount importance to the student.

THE UNITED STATES

The United States of America is a land of unspeakable interest in many directions. It is the most wonderful sociological laboratory that the world ever knew. All the industrial, economic, social, ecclesiastical, and political problems that concern humanity are here in the crucible. With a rapidly increasing population of nearly eighty millions, giant cities are springing up in which the most advanced civilisation is in full evidence.

When to Visit America. The best periods of the year for a visit to the United States are spring or early summer, from the middle of April to the beginning of July, and autumn, from the beginning of September to the middle of November. The weather is, at these times, generally settled, and the atmosphere is enchanting. At other seasons extreme heat or cold, heavy and continued floods, or violent storms, are apt to render travelling exceedingly uncomfortable. June is charming, and above all, the "Indian summer" of October, which so amazed the Pilgrim Fathers and Puritans at first, is exquisite in its wonderful displays of autumnal tints and delicious temperature. The land then overflows with fruit.

A month's absence from England is often used by holiday travellers for what is, of course, an exceedingly brief sojourn in so vast a country, seeing that the first and last weeks are entirely absorbed in the voyages out and back. The quickest lines only allow of such speedy transit. But during a fortnight, a never-to-be-forgotten glimpse may be enjoyed of New York, Brooklyn, Philadelphia, Washington, Baltimore, Buffalo, Boston, Niagara, and Detroit.

A Month in the United States. Quite a month should be taken if anything like a real idea of some few of the most important parts of this wonderful country is to be gained.

First Day to Fifth Day. New York: The *City Hall Square*, the centre of the town, where are the splendid newspaper offices in greatest number. The two *Suspension Bridges* over East River. *Broadway*, the chief artery of traffic. *Fifth Avenue*, with the mansions of the multimillionaires. *Astor House*, the old business hotel and restaurant. *Waldorf-Astoria Hotel*, the most palatial in the world. The mammoth *Stores* of Siegel, Cooper, Wannamaker, Macey, Altmann, and other firms. A ride on the *Hudson* past the *Palisades* and on to *Tarrytown*, the home of Washington Irving. The great *Astor Library*. A drive through *Central Park*. The new and immense *Zoo*. *Columbia University*. The chief *Churches*, including Grace Church, the Roman Catholic Cathedral, Trinity, Fifth Avenue Presbyterian. A stroll in *Chinatown*. A walk along *Bowery*. *Riverside*, with Grant's splendid tomb.

Sixth Day. Brooklyn: *Plymouth Church*, scene of Henry Ward Beecher's ministry. His statue in the *Town Hall Square*. *Greenwood*, the beautiful cemetery. A drive to *Jamaica*, as a sample of a lovely suburban residential village. Ride to *Coney Island*.

Seventh and Eighth Days. Across the Hudson in New Jersey State. Ramble for a day round the beautiful district of *Montclair*, in which live the majority of New York's editors, journalists, authors, artists, etc. Next day take a trip from Montclair over the *Orange Mountains* and visit *Eagle Point* for the glorious view.

Ninth Day. Visit Paterson, with its famous silk mills, and Newark, the American Birmingham. Also, near by, the lovely little town of Madison, a residence of millionaires.

Tenth Day. Hartford, the capital of Connecticut, is a beautiful sample of an American city. *Bushnell Park*, with exquisite Fountain, and fine Memorial Arch. The magnificent *State Capitol*, one of the most beautiful of all American buildings. The famous *Charter Oak Tree*, *Trinity College*, *Colt Memorial College*, *Mark Twain's House*.

Eleventh Day. The beautiful Park called the *Common*. The *Frog Pond*. The lovely *Maid of the Mist Fountain*. *Beacon Hill*, with the fine State House on summit. *Old South Church*, and *Old North Church*, with Paul Revere's Signal Lanterns. *Faneuil Hall*, the "Cradle of American Liberty." The *Old State House* with "Independence Window." North Square, with *Paul Revere House*. The beautiful *New Public Library*. *Museum of Fine Arts*. *Commonwealth Avenue*, with Garrison's Statue, *Massachusett's Institute of Technology*, and *Leif Ericson Statue*. The city is compact, and all may be seen in a day if needful.

Twelfth Day. Journey to Buffalo.

Thirteenth Day. Buffalo is a beautiful city, and can be seen in a day. Its suburbs are especially fascinating. The town contains 80 churches, many being splendid structures. *Main Street*, two miles long and 120 feet wide; *City Hall*, cost £400,000; the *Post Office*, the *Park*; the *Buffalo River*, are the chief points of interest. *Lake Erie* is only two miles from that city.

Fourteenth Day. Niagara is reached from Buffalo by car ride of only 20 miles. See American and Horseshoe Falls; Goat Island; Luna Island; the pretty town; the Rapids above the Falls; the Cataract below, the wonderful Gorge, and the Suspension and Railway Bridges.

Fifteenth Day. Journey to Detroit.

Sixteenth Day. Detroit. One of America's loveliest cities. See the beautiful *Detroit River* between Lakes Erie and St. Clair; magnificent *Roman Catholic Cathedral*, fine *City Hall*; beautiful *Opera*

House; great *Custom House*. The city extends for seven miles along the riverside.

Seventeenth and Eighteenth Days. Journey to Cincinnati. This magnificently situated city, which used to be styled the "Queen of the West," is on the great Ohio River, looking across into Kentucky. The visitor is here on the northern edge of the Southern belt. Cincinnati is celebrated for its superb ring of suburbs, all situated on wooded hills. It lies in the lap of these heights. The *Music Hall* is one of the finest assembly buildings in the land.

Nineteenth Day. Louisville: This is the handsomest city in Kentucky. The *Falls of the Ohio*; *Main Street*, three miles long, a magnificent avenue; and the fine *Court House*, are the chief sights. Great tobacco and other factories.

Twentieth and Twenty-first Days. Two days are needed for journey to St. Louis and survey of city and its environs. It is the most important city of Missouri, and stands on the great Mississippi. It possesses a fine *Court House*, splendid *City Hall*, several of the world's largest hotels, and many fine public buildings, as well as the *Washington University*. There are many immense factories and warehouses. The *Custom House* cost £1,000,000.

Twenty-second and Twenty-third Days. Chicago is, like New York, a "City of Skyscrapers." It has the finest *University Buildings* in America. The great *Armour Packing Establishment*; the great *Armour Educational Institute*; the famous *Grain Elevators*; the vast *Lumber Market*; many magnificent churches and palatial business houses comprise its objects of interest.

Twenty-fourth and Twenty-fifth Days. Journey to Washington. The visitor might elect to take Chicago first before St. Louis and Louisville. But either way he cannot see these great northern cities and also take a trip south to Washington without a long journey.

Twenty-sixth Day. Washington is certainly the city of which America is proudest. Its chief sights are: The *Capitol*, all of white marble, with Senate House and House of Representatives; the *National Library*, one of the most sumptuous buildings on earth, also of white marble; the *Washington Obelisk*; the magnificent *Avenues*, and the *White House*.

Twenty-seventh Day. Visit the *Potomac* and take a trip on the river to *Mount Vernon*, the beautiful home of Washington. The Graves of Washington and his wife are in the grounds.

Twenty-eighth Day. Baltimore is a beautiful city, called by the natives the "Monumental City," and also the "Oriole City." Many beautiful monuments, of which the most famous is the elegant *Obelisk*, in honour of the defenders of the city in 1815; the *John Hopkins University*, America's greatest scientific institution; the *City Hall*, one of the finest buildings in the States; and the magnificent *Roman Catholic Cathedral*, with celebrated organ; all worthy of a visit.

Twenty-ninth Day. Philadelphia is the largest American city in area, extending over 22 miles in length. It is a historic and beautiful city, and possesses numerous fine park-squares. *Independence Hall*, where was signed the famous Declaration of Independence; the *Academy of Fine Arts*, with gallery of over 1,000 pictures; the *Girard College*, of white marble; the *Pennsylvania University*, with America's best medical school, are its leading features of interest.

Thirtieth Day. Back to New York.

Longer Tours. It is impossible to tour through both the Eastern and Western States in less than two months. The most eligible Western extension is through Kansas, Colorado, Utah, and Nevada, into California. An excellent plan is to return by the northern route through Oregon, Washington State, Idaho, North Dakota, and Minnesota and Wisconsin.

Travel, Food, and Expense. America is not an economical country for travel. The average railway fare is three cents (three halfpence) per mile. Many meals must be taken on the train, and the price for each of these is a dollar. But fried chicken, fruit, cakes, etc., can always be had at the stopping points. The cost of a sleeping berth is ten shillings on most lines, in addition to the fare for the journey. There are no separate classes of carriages. Hotel accommodation is usually more expensive than in European countries, and service is specially costly, laundry charges being high. Feeding is luxurious. But the dietetics of America induce serious tendencies to dyspepsia.

Literature. We may specially commend Steevens's "Land of the Dollar," Lovett's "United States Pictures," Sala's "America Revisited," Rebecca Harding Davis's "American Life," Brydge's "Uncle Sam at Home," Archer's "America of To-day," Vivian's "Notes of a Tour," Max O'Rell's "Frenchman in America," Dean Hole's "Little Tour in America," Hatton's "To-day in America," Foster Fraser's "America at Work," and Manning's "American Pictures."

CANADA

The "Land of the Maple Leaf" is at length taking its rightful place in the esteem of those who desire to see other countries than this. It is a magnificent region, of an extent difficult to realise by mere examination of the map. Its climate is one of severe extremes—but they are eminently salubrious extremes—described as "honest heat in summer, and honest cold in winter," with glorious sunshine through the year. The fertility of Canada is almost unrivalled, and its food-producing capacity is absolutely incalculable. Its grand forests and prairies are gay with wild flowers and tobacco. Indian corn, melons, peaches and grapes flourish prodigiously. Roots of all kinds grow to monstrous weight. Its old cities are full of historic fascination for the visitor; and its lakes, rivers, and mountains make up a panorama of superb scenery which could not be explored in the longest lifetime. Being now only eight days from our shores, Canada is easily accessible.

How and When to Visit Canada. Many tourists, very unadvisedly—to save forty-eight hours—reach Canada by the comparatively dull route viâ New York. They thus incur more trouble and expense, and miss the wonderfully beautiful voyage up the St. Lawrence to Quebec. The best time to visit Canada is in the autumn, when the country is seen in its loveliest garb, and the atmosphere is both delightfully balmy and also extremely exhilarating. At that season, the northern and shorter of the two routes past Newfoundland is in regular use. This is the Belle Isle route.

A Month in Canada. Not less than a month is necessary for the tourist who would see the chief points of interest, even in the eastern half of the Dominion.

First to Third Days. Quebec, superbly situated, is a monumental city, full of memorials of the old French days. The chief sights are: the *Ursuline Convent*, in which most of the young ladies of the city are educated, and in the chapel of which is a monument to the Marquis Montcalm, whose skull is reverently preserved; the old *Hotel Dieu*, still marked with British cannon balls; the great *Laval University*, with its towering ancient and modern buildings, and also with the finest collection of pictures in Canada; the fine new *City Hall*, of greystone; the Basilica, or *French Cathedral*, richly decorated within and containing many valuable paintings by Vandyke and others; the *English Cathedral*, containing in a little chapel the body of Montcalm; the lofty and massive *Citadel*, and the famous *Plains of Abraham*; the *Provincial Parliament* buildings, a fine block of greystone in the French Renaissance style.

Fourth Day. *Falls of Montmorenci.* One of the most beautiful scenes in the environs of Quebec; also the historic headquarters of General Wolfe—a long, low-raftered, typical French-Canadian cottage.

Fifth Day. By the little branch railway to the celebrated pilgrimage *Church of St. Anne de Beaupre*, visited by immense numbers of devotees.

Sixth to Eighth Days. Montreal. Here the tourist will visit the immense and imposing *Roman Catholic Cathedral*, with two tall square towers, the celebrated *McGill University*, called the "Pride of Montreal", *Mont Royale*, or the Mountain, the most beautiful city park on the whole American continent, with glorious view, the splendid *tubular railway bridges* on the Grand Trunk and the Canadian Pacific, the beautiful *Chateau de Ramesy*, 200 years old, a wonderfully interesting building in the heart of the busy city, containing a great store of pictures, relics, curios, and treasures of every kind connected with old times, both English and French, the *Viger Gardens*, the Dominion Square; the *Place d'Armes* and the great modern *Cathedral of St. James*, with frescoed dome 250 feet high.

Ninth Day. *Lachine Rapids.* This expedition from Montreal down the last and most violent falls of the St. Lawrence is a terrific experience, but absolutely safe on the small steamer in skilled hands. The traveller now makes for the Province of Ontario, the heart and centre of Canada

Tenth to Thirteenth Days. Ottawa. Here is reached the proud capital of the Dominion Government. The grand *Parliament Buildings* are magnificently seated on a lofty hill, commanding a view of the Ottawa and of vast stretches of forest, plain, and mountain. The *Senate Chamber*, the *House of Commons*, with its detached wings containing various public departments, the *Library*, one of the most beautiful buildings in the country, and the immense lumber works on the River Ottawa, are all worthy of inspection. The town of *Hull* opposite, with its vast lumber yards, and the *Falls of Chaudiere*, a mile distant, should also be visited.

Fourteenth to Seventeenth Days. Toronto is in many respects the most interesting of all Canadian cities, and may be considered the real heart of the country, the focus of the nation's life and activity. It is also a very beautiful city laid out in regular parallelograms, with fine substantial buildings, in splendid streets. It has a quarter of a million inhabitants, and many flourishing industries. Visit *St. James's Cathedral*, *Toronto Club*, *Queen's Park*, *University*; *Trinity College*, in magnificent grounds, *Victoria Presbyterian*, and *MacMaster Baptist Colleges*, splendid establishments; *Parliament House*, a single chamber; and *Osgood Hall*, with law courts, libraries, and judges' chambers.

Eighteenth Day. Hamilton should be visited as a typical Canadian town, handsome and prosperous, with 60,000 inhabitants. It is only 35 miles from Niagara and 45 from Toronto, on the west end of Lake Ontario, and is a great railway centre, with big locomotive and car works.

Nineteenth Day. Leave Toronto by boat-train about mid-day, and in three hours, passing through pleasant farming country, reach Owen Sound, on Georgian Bay, Lake Huron. This is a typical lake-shore town, with about 6,000 people. Here the tourist takes one of the fine Clyde-built Canadian-Pacific steamers plying on the two inland seas, Huron and Superior. The voyage is very picturesque, the first stage being outside the archipelago of islands fringing the eastern coast of Lake Huron for 15 hours, then up the Narrows between the islets to Sault St. Marie. Then the rapids with their famous locks.

Twentieth Day. Sault St. Mary, generally called "The Soo," is a place of growing importance. The wonderful *Rapids*, a mile wide, and the largest *pulp mills* on earth (wood-pulp to-day makes four-fifths of the world's paper) are to be noted here.

Twenty-first Day. Steamer voyage along Lake Superior to Thunder Bay, 300 miles.

Twenty-second Day. Thunder Bay, with two towns, *Port Arthur* and *Fort William*, at mouth of the Kaministiquia River. Mighty *elevators* for Manitoban wheat, the grand *Thunder Cape*, the splendid spruce, cedar, and tamarak forests behind the towns, clothing the hills, are the main items of interest

Twenty-third Day Rail from Fort William to Winnipeg on Canadian-Pacific line, through the romantic Rainy River district of New Ontario into Manitoba, passing through the vast virgin forest

Twenty-fourth Day. Winnipeg is a young but handsome and enterprising city of 50,000 people. Its streets are wider than those of any other city in the world, and it is built on deep, rich, black earth, with fine buildings of redstone, greystone, and red or white brick. There are splendid educational institutions, including the *University* and *St. John's*, *Manitoba*, and *Wesley Colleges*. The *Grand Square*, with tall column commemorative of Canadian soldiers who have fallen in battle, the imposing *Parliament Buildings*, the fine *City Hall* and spacious *Market*, are all interesting, and not less so its most cosmopolitan population Spend 25th day here also

Twenty-sixth Day. The tourist should begin the "all rail" return journey Having come to Winnipeg by the Lake route, he should go back by rail to Lake Nipissing, traversing a most picturesque region, famous for hunting, fishing, and lumbering.

Twenty-seventh Day. Notice the Ratt Portage on *Lake of the Woods*, the lovely scenery. This is the centre of sawing and milling, and also the headquarters of a splendid sporting district.

Twenty-eighth Day. Lake Nipissing.

Twenty-ninth Day. Ottawa.

Thirtieth Day. Montreal. Thus, the tourist has enjoyed a month's leisurely and fairly complete survey of one of the grandest sections of the British Empire. If he can spare a second month, he can undertake the journey farther west, and can make acquaintance with the great ranching, wheat-growing, lumbering, and salmon-canning region of Assiniboia, Alberta, and British Columbia. Here he enters on an entirely new world.

Canada is a land of profuse hospitality. Its people love to greet and oblige interested and inquiring strangers. In the leading hotels of the great cities the tariff varies from three to five dollars a day; in smaller hotels in these cities, and in the best hotels in the country towns, it ranges from two to three dollars.

Books on Canada. The best books are "Canadian Pictures drawn with Pen and Pencil," by the Duke of Argyll; "Canada in the Twentieth Century," by A. G. Bradley; "The Canadian Dominion," by C. Marshall; Lady Dufferin's "Journal"; "Through Canada with a Kodak," by the Countess of Aberdeen; "To Canada with Emigrants," by J. E. Ritchie; Monck's "My Canadian Leaves"; Sladen's "On the Cars and Off"; and Roper's "By Track and Rail Through Canada."

Continued

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CYCLOPÆDIA OF SHOPKEEPING

CHEMISTS AND DRUGGISTS. Apprenticeship to Proprietorship. Examinations. Fittings and Stock. Side Lines. Profits

CHEMISTS AND DRUGGISTS

Generally speaking, a registered chemist is regarded merely as a superior type of shopkeeper—a man who sells drugs, medicines, and toilet sundries in much the same way that a grocer vends his particular class of wares. Comparatively few realise that the chemist, even the owner of a small shop in the meanest back street of any town in the country, must be a man of considerable attainments and not a little scientific knowledge.

Preliminary Examination. One of the first essentials for a successful chemist—or pharmacist, as he prefers to be called—is a liking for, and knowledge of, chemistry. For upon that science hinge the elemental principles of pharmacy, although chemistry is only one of the subjects of which a pharmacist ought to possess an intimate knowledge. The youth contemplating pharmacy as his life-work must therefore have a liking for "that branch of knowledge which teaches the properties of elementary substances and of their mutual combinations." He must likewise be fairly well educated For, before being apprenticed to a registered chemist, he ought to pass a preliminary examination, such as is recognised by the Pharmaceutical Society of Great Britain, and which includes English grammar and composition, arithmetic, algebra, Euclid, Latin, and a modern foreign language. The passing of this examination before apprenticeship is preferable in every way, but not compulsory. It may be taken during the apprenticeship period, but such a course wastes time which would be better occupied in the acquisition of practical knowledge.

Apprenticeship. The "Preliminary" having been successfully negotiated, a pharmacist with a good all-round business should be selected for the mentor of the future disciple of Galen. The best training for the youth is obtained in a good mixed business in a provincial town. There he has a chance of learning all departments of the trade better than in a purely dispensing business, or in a pharmacy in London or one of the larger cities, where work runs more often than not in a groove. Indoor apprenticeships in England and Wales were at one time almost the only means of training. Present day practice is tending to discourage the indoor system in pharmacy, and the outdoor apprenticeship, which has always held good in Scotland, is being more generally adopted. In the case of indentured apprenticeships, premiums of from £50 to £100 are required, according to the class of business; but a small weekly wage is usually paid to the apprentice engaged under the outdoor or Scotch system. The period of apprenticeship is from three to five years. Of course, one need not be apprenticed to a chemist at all, but in order to qualify for the Minor examination of the Pharmaceutical Society it is necessary that the student has either been registered as a student of pharmacy for three years, or that for three years he has "been practically engaged in the translation and dispensing of prescriptions." Some youths put in the requisite three years as "dispensers" to doctors, or help in the dispensaries of hospitals or other public institutions, but it will be recognised at once that such a training is too circumscribed and meagre for business success in after life.

Examinations. When the apprenticeship period is over, the next best thing for the young man is to turn his thoughts seriously towards the passing of the Minor Examination, which qualifies him as a "chemist and druggist." This is a statutory examination conducted by the Pharmaceutical Society of Great Britain, whose headquarters are at 17, Bloomsbury Square, London, W.C The legal requirements of the Acts pertaining to pharmacy are that no one may assume, take, or use the title "chemist and druggist," or "dispensing chemist," or "pharmaceutical chemist," or keep open shop for the sale of poisons, or sell poisons as named in the schedule of the Act, unless he or she satisfy the examiners of the Pharmaceutical Society of his or her ability and thereby secure registration under the Act. This examination requires a fairly wide knowledge of botany, chemistry, and physics, materia medica, pharmacy, practical pharmacy and dispensing, and prescription reading.

Certificates. If the apprentice has been serious, studious, and observant, and has taken advantage of all the benefits of evening courses at local technical schools or colleges, he may go up and pass without any special tuition. But the scope of the examination has been so widened, and the subjects have been so elaborated during recent years, that it is almost a necessity to take a course or two at a school of pharmacy, of which there are many in London and the larger provincial towns. The average fee for a three months' course, during which the examination subjects may be covered, is £10 10s. Of course, books, some reagents, and the cost of board and lodging, have to be taken into account over and above the fees. Before presenting himself for examination the candidate must be twenty-one years of age, and must pay an examination fee of £10 10s. If successful, he is registered and can not only start as a chemist and druggist on his own account, but has also materially increased his pecuniary value as an assistant. A higher examination (entrance fee £3 3s.) is known as the Major Examination. This entitles the aspirant to call himself a "pharmacist," a "pharmaceutical chemist," or a "pharmaceutist," but it is purely honorary. Its only practical value in after life, beyond giving the holder a certain higher status, is that it exempts him from jury service. These examinations are held at the headquarters of the Pharmaceutical Society and at the Scottish branch, 36, York Place, Edinburgh.

Assistantship. Before launching into business a wide and varied experience is necessary. The young man should endeavour to secure an assistantship, or a series of assistantships, in businesses of different types. A year or two spent in a good-class West End London pharmacy is useful in after life, but berths in these are often indoor, with long hours, night duties, and small salaries. The improver—unqualified—may receive a salary varying from £30 to £50 per annum indoors, or from £1 to £1 10s. weekly if the situation be outdoor. The qualified assistant commands much higher remuneration; £60 to £120 per annum indoors, and £2 to £3 10s. per week outdoors being usual, according to experience and ability. A Continental experience is of incalculable benefit, not only on account of the kudos to be obtained, but also as an aid to general culture and the broadening of the pharmacist's somewhat restricted vision. Pleasant and profitable engagements may be secured in France and Germany, and one or two seasons in some of the Riviera or other fashionable Continental wateringplaces are easily procurable by capable men

Starting in Business. One of the great drawbacks in the semi-professional training necessary for a chemist is that business principles are often neglected, or at best are imperfectly taught. It is notorious that the generality of chemists are bad business men. The advantage of knowing all phases of the business—high-class dispensing, family and retail, a touch of wholesale, a spice of agricultural, and "heavy trade" (by which is meant dealing in oils, paints, colours, sheepdips, etc.)—need scarcely be insisted on, and in opening a shop, each individual must endeavour to follow his idiosyncracy and to expand in the department in which he is strongest.

With regard to location, it is notable that a corner shop is the one most sought after, and the most desirable. A growing neighbourhood should be fixed upon, provided an entirely new start is to be made, and the success of the business depends in a great measure on the foresight of the beginner in this particular. We have in mind the owner of over a dozen pharmacies in a large provincial town, who made it a practice to explore the promising suburbs of his town in his spare time. In a likely spot where building operations were going on, he interviewed the builder, bespoke a nice corner shop, and when the building was sufficiently advanced, had bills posted in the windows, informing the passers-by that this shop was taken for So-and-so's pharmacy, and would be opened in a short time. In many instances, the shop was not fitted-up or opened for quite six months after the notices had been posted; but meanwhile the neighbourhood had been growing, and competitors were scared off.

Capital and Outlay. As in other businesses, the question of capital required cannot be definitely stated. The most successful businesses in pharmacy have been built up from small beginnings. Some years ago, one man gave in a trade journal his experience of how he started with six-and-sixpence, and in a few years made a respectable living. He was, however, probably a man of transcendental ability and business acumen. But many good chemists' businesses have been built up on an initial outlay of from £200 to £400; the amount of capital required depends entirely on the neighbourhood selected, the class of business to be done, and the style of shop.

A large capital is not by any means a necessity, and looked at from a purely commercial point of view, it is evident that capital invested in the business of a chemist and druggist—which is purely personal—should yield a relatively greater return than money spent in purchasing any ordinary marketable security. Businesses, well established or otherwise, and of all kinds, are, of course, to be purchased at prices ranging from, say, £100 to £1,000, but we may imagine a young qualified chemist with £400 to spend, who has found what he thinks is a suitable site for a new business.

Shop-fittings. After securing a lease, and starting an account at a local bank, he proceeds to the shop-fitting. This may be done for £50 upwards, but in the present instance, about £150 would be the sum spent on internal fittings. These would include the usual window enclosures, counters, and wall fixtures. The window enclosures have on top iron bar tramway lines, for the attractive coloured carboys that are the insignia of the craft in the eyes of the public. Behind the counter, and below the partitioned wall-fittings, there are rows of drawers, under which are lockers for bottles and covered pots for ointments. A small poison-cupboard in some out-of-the-way corner is a necessity. There would be a dispensing counter, with probably a mirror and marble slab in front, glass cases for the serving counter, and uprights for holding perfumes and toilet articles. Regular suites of pharmacy fittings may be purchased from shop-fitters who make a speciality of chemists' shop-fittings, and a very good show can be made for the sum named.

The accompanying illustration [1], which is of a shop fitted by Messrs. Maw, of London, gives an idea of how a long, narrow shop may be adapted to a chemist's business to the best advantage. The approximate cost of fitting in mahogany, or other hard wood such as oak or American walnut, is as follows:

Drawers for drugs, each fitted with a cut-glass label and knob. Lockers for bottles, etc., under the drawers. Ornamented pilasters, with carvings, shelving for shop bottles and jars. Cornice with pediments and other decorative work, about £2 10s. 0d. per foot in length.

Wall show-cases, all glazed with plate-glass, with bent glass doors where required, as indicated in 1. Movable plate-glass shelves in the upper cases, and with carvings and other decorative work, about £5 0s. 0d. per foot in length.

Window enclosures, about 6 feet high from floor of shop. With modern arrangement of plate-glass shelving and mirrors, complete, about £3 0s. 0d. per foot in length.

Serving counter with plate-glass show-case front, about £1 5s. 0d. per foot in length. (Curved portions about double the price of straight portions.) Drawers at back extra, about 5s. per drawer.

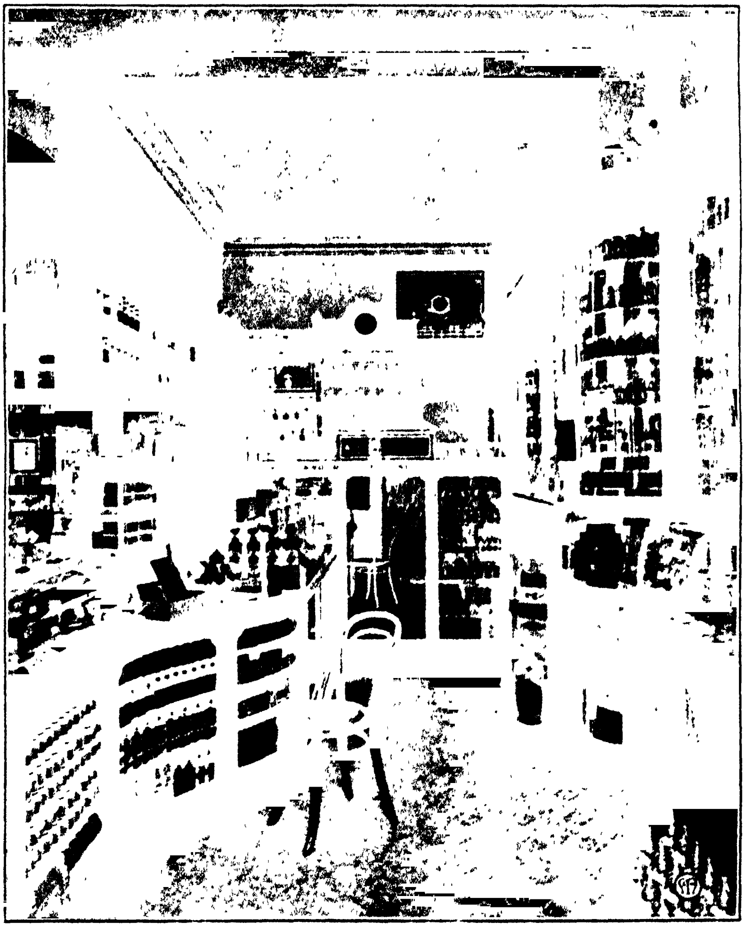
Dispensing screen, with counter and all back fittings (as shown in 2), mirror backs and plate-glass shelves to the cases, about £5 0s. 0d. per foot in length.

Bent plate and other show-cases for the counter top from £1 5s. to £2 per foot in length.

The same designs can be executed in less expensive materials, such as American white wood, properly stained and French polished to a superior imitation of mahogany or walnut, at a reduction in cost of 20 to 25 per cent.

Chemists will find it to their advantage to consult a specialist in chemists' shop fittings, whose experience in planning work for this purpose will ensure the most satisfactory result for whatever amount it is decided to spend.

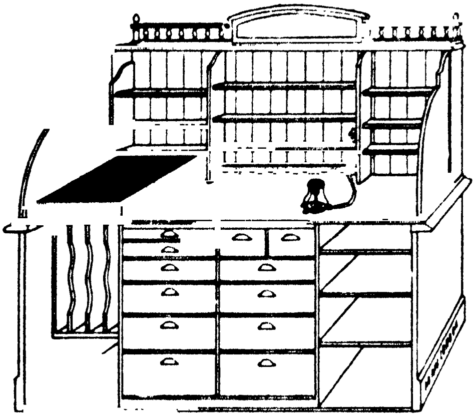
Accessories. Behind the dispensing counter it is advisable to have a lead-lined sink at handy distance, and a gas-stove, a bunsen burner, and a horizontal gas-jet for sealing. Fig. 2 gives a suggestion for the best arrangement for the back fittings to a dispensing screen. It comprises one drawer fitted for shop labels, one drawer fitted for cut papers, and a third for corks; a desk with rack beneath for prescription book; shelves for pill machines, mortars, etc.; movable shelves (on top at the back of the screen) for holding bottles, jars, etc., filled with solutions, ointments, etc., ready for use in dispensing; a wax-jet and a gas union for the bunsen burner. The £150 can be made to include also the outside lamp, window blinds, floor covering, painting outside and papering inside, and the insertion of a mosaic step in the doorway. Another £50 will have to be expended on shop bottles and jars for holding stock, utensils, and apparatus, such as counter scales and weights, dispensing scales and weights, measures, medicine and soda-water baskets, earthenware pestles and mortars, pill machines, ointment slabs, evaporating dishes, suppository bath and moulds. And the multifarious adjuncts requisite for the technical operations of pharmacy will cost another £20. Labels and stationery, bottles and boxes require £40 more, and the same sum is needed to secure a working supply of drugs and chemicals. Then a modest stock of lozenges, perfumes, coated pills and mineral waters may be put down at £21 10s., while another £20 may be spent on soaps, sponges, homœopathic medicines, etc., leaving £30 for patent medicines and proprietary medicines, and £25 for druggists' sundries



1. INTERIOR OF MODERN PHARMACY, SHOWING ADAPTATION OF VERY NARROW SHOP TO DRUG-SHOP FITTINGS

By the last named is meant feeding-bottles, hair and tooth brushes, dressing combs, chest protectors, corn and bunion plasters, eye-baths, enemas, food-warmers, bedpans, and many other surgical necessaries.

Prices. The best paying businesses are those in which a purely dispensing business is done. But these are few and far between, and it has been said, with some degree of truth, that not two per cent. of the pharmacies in the country are kept open on pure pharmacy. As it is in the dispensing of prescriptions and the compounding of the galenicals for use in dispensing that the highest art of the pharmacist is exercised, it is only just that this branch of pharmacy should be the most highly remunerated. There is therefore a recognised scale of prescription prices which is more or less adhered to all over the country. For instance, if we take a 6 oz. mixture as a typical example, the average price, irrespective of ingredients, would be from 1s. to 1s. 4d. according to the locality in which it is dispensed. Of course, should it happen that an expensive ingredient, such as a synthetic chemical costing 3d. per grain were present in any quantity in the mixture, the price would have to be materially increased. The average cost of an average prescription calling for a 6 oz. mixture would work out, calculating price of bottle, cork, label and cap, at probably 4d. or 5d., so that the remuneration to the pharmacist for his skill, care, knowledge, time, etc., is from 7d. to 11d on the transaction. This looks a large profit, but one must not forget that the pharmacists' business is not by any means devoted entirely to dispensing 6 oz. mixtures. These are the occasional fees which the course of study, cost of examination, and his semi-professional position entitle him to expect.



2. ARRANGEMENT FOR DISPENSING-COUNTER

Proprietary Medicine. Such is the bright side of the picture. Now for the reverse. As mentioned above, not two per cent. of chemists live by pharmacy alone. The adjuncts to the chemist's trade provide livelihoods for the other 98 per cent. Twenty years ago these adjuncts, such as proprietaries (or patent medicines as they are more often called), perfumes, toilet articles, and fancy goods bore a fair profit. But within recent years departmental stores have opened drug sections where proprietaries, perfumes, and the more popular household preparations commonly obtained from the chemist, are sold as a draw at almost cost prices. This principle of cutting prices has extended enormously within the past few years, much to the detriment of the chemists' calling. Many qualified chemists themselves started the "cutting" scheme, and limited companies calling themselves "cash chemists" have sprung into being and make a virtue of low prices. To such a pass did the cutting of proprietaries in particular come that not so many years ago a proprietary medicine with a face value of 1s. 1½d. would be sold universally at 10½d., the wholesale cost being 10½d. This parlous state of things has been mitigated somewhat, however, by the work done by the Proprietary Articles Trade Association. A chemist in the East End of London, Mr. W. S. Glyn-Jones, propounded an anti-cutting scheme, which in effect meant that manufacturers and wholesalers would agree to sell their goods only to such retailers as consented to retail them at a certain fixed minimum price, this price being such as left a fair profit for handling to the retailer. Thus, the 1s. 1½d. proprietary would not be retailed under 1s., and so on in proportion to the selling rates of the goods. The scheme was pooh-poohed at first, but at the present day the P.A.T.A. is a power in the land. Almost all the proprietary medicines of note are on the "P.A.T.A. protected list," and nowadays no new proprietary is put on the market without having the retail price protected.

Side Lines. The cutting of prices and the subsequent degeneration in the art of the pharmacist proper have driven the chemist more and more into bypaths of commerce. To counteract the ruinous handling of unremunerative patent medicines, widely advertised, and therefore in considerable demand, many chemists now put up proprietary medicines of their own. The smart, up-to-date chemist has his own brand of liver pills, neuralgia mixture, blood purifier, digestive syrup, cough balsam, and what not, on which he has a good profit and which he has confidence in recommending to his customer. The personality of the chemist's business gives him a big pull in this particular over other tradesmen, and the smart man does not fail to take full advantage of it. Many chemists, especially in busy provincial towns and in poorer neighbourhoods, lay themselves out for counter-prescribing. Simple remedies are supplied for simple ailments, and in some districts the prescribing chemist is a boon to his poorer neighbours, and builds up a lucrative business for himself.

The legitimacy of counter-prescribing has often been questioned, especially by the medical profession; but a chemist, if only for the sake of his own reputation, never oversteps the limit where the attendance of a doctor, with a more intimate medical knowledge, is necessary.

Photographic Materials. One of the most popular and profitable of pharmaceutical side lines is the sale of photographic materials. The chemical agents required by those practising the "black art," either as professionals or amateurs, are a by no means inconsiderable source of profit, but in order to make the photographic side line a thoroughly paying one it is necessary that the chemist himself be at least an amateur photographer. In most cases the photographic chemist has a dark-room fitted up for the convenience of his clients, but in all cases, if the photographic department is touched at all, it should be done thoroughly. [See also PHOTOGRAPHIC DEALERS in this Course.]

Optical Goods. Within the past few years optical goods and the sale of spectacles have been added as a side line, and it is increasing in importance. This branch ought only to be undertaken by such men as have qualified in sight-testing, and who have acquired more than a superficial knowledge of the subject. [See also OPTICIANS.]

Veterinary Remedies. In agricultural districts a veterinary knowledge is very useful. There are special veterinary preparations, such as horse and cattle medicines, sheep-dips, poultry foods and poultry medicines, sheep, pig, and dog remedies that all agricultural chemists make it their business to stock. To be able to advise, and in some instances to prescribe, simple remedies for animals is almost a necessity in such cases.

Aerated Waters. The manufacture of aerated waters is often found in connection with chemists' businesses, especially in provincial towns. The public, fastidious in some things, often prefer the aerated waters which bear a chemist's label; so the chemist embarking on the business should see to it that his waters are superior in quality, preparation, and general "get-up" to those in his neighbourhood, otherwise the game is not worth the candle.

Soda-fountains. The advent of the American soda-fountain has added yet another to the chemists' side lines. In America the soda-fountain is part and parcel of a chemist's shop fittings, and the more magnificent the fountain the more popular the "druggist," as he is known in the States. It is only within recent years that the fountain has obtained anything like a footing in this country, but it looks as though it were slowly gaining popularity, and presumably it has come to stay. It is certainly a very attractive feature to any establishment, and once the chemist of this country has got over the objection to being looked upon as a glorified "bartender," it ought to be made to pay well. Another objection often put forward is that the English climate is unsuitable to the unlimited consumption of temperance beverages, but our American cousins contend that the question is not one of climate but of educating the British public. Good business in seasonable drinks (and their name is legion) is done all the year round in America, and there is no reason why the same should not be done in this country.

3. ARTISTIC SODA FOUNTAIN

We illustrate [3] a soda-fountain made by Stiles, Ltd., of London, and it gives some idea of the elegant appearance even a small fountain may have in a well-appointed pharmacy. The cost of this machine complete, with charging outfit, is 66 guineas.

The profits of a soda-fountain, if a fairly good trade can be done, are large, for, after the initial cost, the material for turning out the drinks is inexpensive, and a good going fountain will show an average profit of anything from 300 to 700 per cent. A useful book to study if this department be taken up seriously, is White's "'Spatula' Soda-water Guide and Book of Formulas for Soda-water Dispensers," price one dollar.

Legal Matters. There are many Acts of Parliament that the chemist will encounter in his business career. The Pharmacy Acts, the Sale of Food and Drugs Acts, and the Medicine Stamp Duty Acts are perhaps the most important of these; but there are others, such as the Merchandise Marks Act, the Revenue Regulations regarding alcoholic liquors, and the laws relating to trade marks and to patents, with which it behoves him to be acquainted. The regulations regarding the sale, compounding, or dispensing of poisons, and the assumption and use of the titles "Pharmaceutical Chemist," "Chemist and Druggist," "Chemist," or "Druggist," are dealt with in the Pharmacy Acts of Great Britain and in the Pharmacy Acts of Ireland. The latter country has an Act of its own, and it is administered by the Pharmaceutical Society of Ireland. The qualifications of the two countries are not interchangeable – that is to say, a licentiate of the Pharmaceutical Society of Ireland is not allowed to practise in Great Britain, and vice-versa.

In Guernsey the pharmacy law restricts the sale of most drugs to licensed chemists, the Minor certificate of the Pharmaceutical Society of Great Britain, or the *pharmacien's* certificate of France being accepted as licence. In 1900, the Legislature of the Isle of Man enacted a Pharmacy Act on the lines of the Pharmacy Acts of Great Britain; but there the registered chemists of this country and the highest diplomates of the Irish society are eligible to practise. Jersey possesses a "Règlement sur l'Exercise de la Pharmacie et la Vente de Poisons," which requires those who practise there to be either a "pharmaceutical chemist," or a "chemist and druggist" of Great Britain or of Ireland, a "pharmacien" of the first or second class of a school of pharmacy of the University of France. The Sale of Food and Drugs Acts and the increasing stringency with which medical officers of health and public analysts are applying it with regard to drugs, make it necessary that the modern chemist in business should be quite certain that his drugs, chemicals, and galenicals are up to the requisite standards of purity and composition.

"Patent" Medicines. The Medicine Stamp Duty Act deals with the stamp duty payable on proprietary or "patent" medicines, as they are usually, but often erroneously, called. Briefly, stamps – according to the specified value of the medicine – must be affixed to all medicinal preparations for which is claimed "any occult secret or art" in the making, any exclusive right or title to the making or preparing, patent rights, or which is held out or recommended to the public (by label, handbill, or advertisement) as a nostrum or proprietary, or as a specific, or as "beneficial to the prevention, cure, or relief of any distemper, malady, ailment, disorder, or complaint, incident to or in anywise affecting the human body." A few years ago High Court decisions altered the method of administration, so that important exemptions were restored to qualified chemists respecting the sale of "known, admitted, and approved" remedies; while, on the other hand, the sale of "ailment-named" remedies—such, for instance, as "Dipsomania Tablets," "Cough Pills," etc.—which had hitherto been exempt, were made dutiable articles.

Colonial Practice. The practice of pharmacy in the British Empire is modelled on that of the Motherland to a great extent, and in most British colonies the British qualification is accepted without further examination. The diploma of Great Britain, and also of Ireland, holds good in all the Australasian colonies (except New South Wales), and in Barbados, British Guiana, Natal, Transvaal, Orange River Colony, Fiji, Gibraltar, Gold Coast, Jamaica, Leeward Islands, Malta, Sierra Leone, Straits Settlements, Trinidad, and the Windward Isles.

In some countries—Canada for instance—the qualifying examinations of the British and Irish societies permit a man to act only as a qualified assistant to a chemist in business. Before the British "Minor" man can open shop as proprietor, he must pass the Canadian Major Examination. India is the only British possession of importance that has no definite pharmacy regulations, but there are indications that "the brightest jewel in our crown" will soon come into line. Suffice it to say that the British chemist with the nomadic instinct will find no great hindrance to the pursuit of his profession in the lands beyond the seas. He will find in the Colonies an outlet for his energies and greater scope for his commercial development. The prices he obtains are higher all round, and there is not—except, perhaps, in some of the bigger centres in Australia and in Africa—the same strenuous competition that is found at home.

Business Books. There are several books that the chemist will find valuable in his business practice. These include Beasley's "Druggists' General Receipt Book," 6s. 6d.; "B. P. C. Formulary," 1s.; Cooley's "Cyclopædia of Practical Receipts," 42s.; Thompson's "Chemists' Compendium," 3s. 6d.; and a series issued by the trade paper, "The Chemist and Druggist"—*viz.*, MacEwan's "Pharmaceutical Formulas," Vol. I., 10s., and Vol. II., 10s.; "Art of Dispensing," 6s.; "Veterinary Counter Practice," 4s.; Ince's "Elementary Dispensing Practice," 3s. 6d.; "Diseases and Remedies," 3s.; Proctor's "Manual of Pharmaceutical Testing," 2s. 6d.; and "Opening a Pharmacy," 2s.

Continued

THE TRANSFORMER

Principles of the Transformer. Ratio of Transformation. Magnetising Currents. Types of Transformer. Insulation. Ventilation

Group 10

ELECTRICITY

12

Continued from page 1590

By Professor SILVANUS P. THOMPSON

Alternating Currents can be Transformed. Among the properties of alternating currents is the facility with which they can be transformed from one voltage to another. Currents generated or transmitted at a high voltage can be transformed down to a low voltage, or those generated at a low voltage can be readily transformed up to a high voltage; and all this without having recourse to any revolving machinery, provided the currents are themselves of the alternating kind. Currents of the continuous kind cannot be so transformed without the employment of revolving machinery with commutators. The stationary apparatus for transforming alternating currents is termed a *transformer*.

Energy Relations in Transformation. It was pointed out, in page 290, that the *power* of any electric current is always the product of two factors, the volts and the amperes, and the product of the volts and amperes was called the number of *watts*, 1,000 watts being called one *kilowatt*. Now, in any transformation it is impossible to get more power out of the apparatus than is put into it; in fact, as there is always a slight loss due to resistance, etc., the efficiency of even the best transforming apparatus is less than 100 per cent.

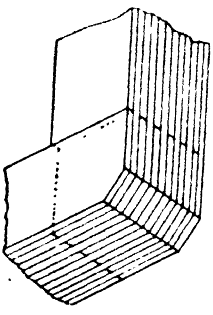
In an electric transformer power is put into the apparatus at one side—called the *primary* side—and an equal amount (save for the small percentage of loss) is taken out at the *secondary* side. Suppose a case where, at the primary side, 20 amperes are being supplied at 1,000 volts; then, supposing that the volts and amperes are in phase [see page 1363] with one another, there is power going in at the rate of 20 × 1,000 = 20,000 watts, or 20 kilowatts.

On the secondary side, the power given out will be practically the same—that is to say, the product of the secondary amperes and volts will be just a little less than 20,000 watts. Suppose that the transformer is designed (we shall see presently how this is done) to give out its currents on the secondary side at the low pressure of 50 volts, how many amperes will there be? Clearly, if the product is to be a little less than 20,000 and one of the two factors is 50, the other factor—the amperes—will be a little less than 400. In fact, if the transformer has an efficiency of 98½ per cent., the secondary output will be 394 amperes. Or, putting it the other way round, if we want to get out 400 amperes at 50 volts, the current we shall have to put in at the primary side at 1,000 volts will be just a little more than 20 amperes—namely, 20·3 amperes, the extra 0·3 ampere being the amount to make up a 1½ per cent. loss.

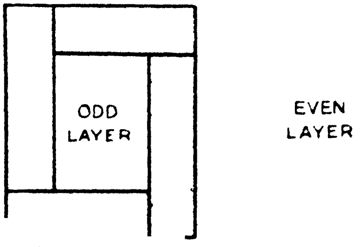
Ratio of Transformation. We see, then, that we can get out at one side of a transformer more current than we put in at the other, provided we arrange to take it out at a lowered pressure. This is just as truly in accordance with first principles as is the action of a lever. A man by pressing on the long end of a pivoted lever can exert ten times as great a force at the other end, provided the fulcrum is so arranged that while he moves his hand downwards through an inch the load at the other end is raised only $\frac{1}{10}$ in. In a lever, whatever is gained in force is lost proportionally in range, and so the energy given out at one end is equal—save for a small friction loss—to the energy that is put in at the other.

So in the electric transformer, whatever the proportion between the two voltages, that between the amperages is practically the inverse. The ratio between the two voltages is called the *ratio of transformation*. In the above example, where the primary voltage was 1,000 and the secondary voltage was 50, the ratio of transformation was 1 : 20; and the ratio of the currents was practically 20 : 1—that is, 400 secondary amperes to 20 primary amperes.

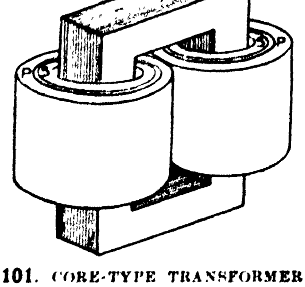
Principle of the Transformer. Like the dynamo and the motor, the alternating-current



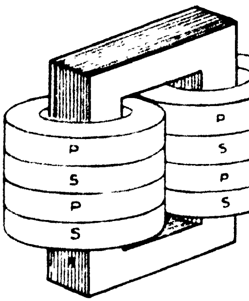
99. CORE-JOINT



100. ARRANGEMENTS OF STAMPINGS IN SHELL TYPE FOR OVERLAPPING



101. CORE-TYPE TRANSFORMER CONCENTRIC COILS transformer has developed from Faraday's classical apparatus. In fact, in its elementary form, as an iron ring interlinking itself with two copper wire coils (the original form constructed by Faraday), it has been already described and depicted [see **37**, page 949].



102. CORE TYPE TRANSFORMER SANDWICHED COILS

Referring back to **37**, the ring, with its two independent insulated coils A and B, let us consider what happens in it when the primary coil A, instead of receiving an interrupted battery current, receives an *alternating current*, such as was described in the chapter on the *alternator* [page 1357]. The alternating current, flowing round the coil A, will obviously create in the iron core an alternating magnetic flux. That is, there will be set up in the iron ring a magnetic flux, the path of which is a closed path within the iron of the ring; and this flux will increase in value to a maximum, will then die away, will reverse in direction, and grow to a negative maximum, and will again die away, repeating this cycle of operations exactly as often as the current that produces it goes through its round of operations. If the primary current has a frequency of 50 cycles per second, the alternating flux will alternate with the same frequency.

Now this alternating flux interlinks itself with the secondary circuit B, and will therefore by its variations induce in the windings of that coil an electromotive force proportional to the intensity of the magnetic charges, and therefore also of the same frequency as the magnetism.

We see, then, that by means of a purely *magnetic mechanism*—*viz.*, interlinkage with the magnetic lines of an iron core—the alternating voltage which is applied to the terminals of the primary coil A is reproduced automatically as another alternating voltage at the terminals of the secondary coil B; and yet there is *never any electrical connection* whatever between the two windings.

Automatic Operation of Transformer. The transformer is automatic in another sense also. Even if the secondary circuit be left open, so that no current flows in it, there will be a voltage induced in it by the alternating flux interlinked with it. When the secondary coil is thus on open circuit, the current that flows into the primary coil from the alternating mains will be merely a magnetising current, of small amount, and will be practically a wattless current [page 1364], as the amount of energy lost in magnetising is trifling. What, then, will happen if the secondary circuit be closed through a resistance? In that case there will be a secondary current, and it will give out power and heat the resistance through which it flows. This power must come from somewhere, and the only way from which it can come is through the primary circuit by more current flowing in from the mains. If this were not so, we should have—what is impossible—a creation of energy out of nothing. So as we draw current from the secondary side, and the more we draw, so, automatically, does more and more current flow into the primary side from the mains.

Magnetising Current. As the whole operation of the transformer depends on the magnetism of the iron core, which, with its alternating flux induces the voltage in the secondary, it is clear that even when no current is being drawn from the secondary, a current must still flow in from the primary mains to keep the secondary circuit "alive." This magnetising current at no-load will, however, be a relatively small current, because, as the iron core is constructed as a closed circuit without gaps, a comparatively few ampere-turns will suffice to create the magnetic flux. Thus, for example, a 20-kilowatt transformer, which, when supplied from mains at 1,000 volts, took at full load a current of 20·3 amperes, was found at no-load to take the insignificant magnetising current of 0·28 amperes.

Ratio of Windings. We have seen that transformers work with some definite ratio between the primary voltage of the supply mains and the secondary voltage at which they give out their current, and that this ratio was called the ratio of transformation. Now, this ratio has nothing to do with the size of the transformer, but depends only on the relative numbers of turns in the two windings on the core. It is, in brief, the same as the ratio of the windings. If we require a transformer to transform down the voltage from, say, 1,000 volts on the primary side to 50 volts on the secondary side—that is, in the proportion of 20 to 1—then the number of turns in the primary winding must be 20 times as great as the number of turns in the secondary winding. For a step-down transformer the primary will have more turns than the secondary. For a step-up transformer the secondary will require more turns than the primary.

We see this rule even in the case of the induction coils used for procuring spark discharges. The primary source is a battery of a few volts, while to produce a spark in the secondary circuit needs the generation of thousands of volts. Hence, the primary winding consists of one layer only of thick wire, while the secondary winding consists of a very fine wire with hundreds of thousands of turns.

If a transformer were made with an equal number of turns in its two coils, it would transform neither up nor down: the secondary voltage would be the same as the primary voltage, and the ratio of transformation would be 1 to 1.

The rule for transformation ratio may be stated in symbols. If S_1 be the number of spirals or turns in the primary winding, and S_2 the number of turns in the secondary winding, E_1 the voltage induced in the primary (practically equal to the applied primary voltage of the mains), and E_2 the induced secondary voltage, then the proportion that exists is simply :

$$\frac{E_2}{E_1} = \frac{S_2}{S_1};$$

and as the currents are inversely proportional to the voltages, it follows that the primary and secondary currents C_1 and C_2 will be connected by the rule

$$\frac{C_1}{C_2} = \frac{S_2}{S_1}.$$

As a matter of fact the actual primary current will, as already indicated, be always slightly greater than the value of C_1, as calculated by this rule, because allowance must always be made for the existence of the magnetising current.

Magnetising Ampere-turns Needed. Attention was drawn on page 1108 to the conception of the magnetic circuit, and an example was there given of the way of calculating how many ampere-turns are needed to excite the required magnetism in a given case. Now, the case of transformers is even simpler, because in its magnetic circuit there are no gaps and the cross-section of iron in its core is uniform throughout. Experience shows that it is not wise (if waste of energy in the iron is to be avoided) to force the flux-density in the cores of transformers beyond a moderate value. As an average figure, a flux-density of 35,000 magnetic lines per square inch may be assumed.

Now, taking good sheet iron or mild steel, such as is used in building the cores of transformers, we may say that experience shows that this flux-density will be attained if we provide an excitation of 3 ampere-turns per inch length of core. Suppose that the core of our transformer had a mean length of 60 inches along the magnetic path, then an excitation of 180 ampere-turns would be about right for it. And if the primary coil had, for example, 1,500 turns, then the magnetising current (at no-load) would be $180 \div 1500 = 0{\cdot}12$ amperes. We have given 3 ampere-turns per inch as an average figure. A more accurate estimate can be got by the following rule. The ampere-turns per inch that are needed will be

$$1{\cdot}2 + (\mathbf{B} \div 14000),$$

where **B** stands for the number of lines per square inch of flux-density. The best kinds of transformer iron—for example, the British quality known as Sankey's "Lohys"—will require even fewer ampere-turns per inch than this.

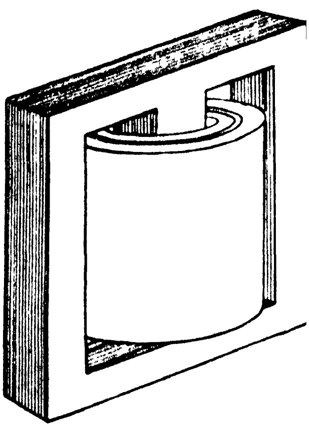
Joints in the Magnetic Circuit. To keep down the magnetising current to a low value, as is necessary if the transformer is to be of high efficiency, not only must the iron be of good quality, but all joints and gaps in the circuit must be avoided, because more ampere-turns are needed (as explained on page 1108), to drive the magnetic lines across air than to drive them through iron. Hence, in the construction of transformer cores it is usual to obviate all joints by interleaving the iron plates by making them overlap at the corners, as shown in **99**.

Forms of Transformers. The practical transformer of to-day differs in many respects from the primitive ring of Faraday. The core is not solid, and is not ring-shaped. If it were solid it would grow hot by reason of parasitic eddy-currents induced in the cross-section of the iron, and these currents would waste some of the energy. If it were ring-shaped the coils would have to be threaded on by hand, and not wound on a lathe. So, instead, the cores are built up of strips of sheet iron or mild steel about 13 or 14 mils thick (*i.e.*, from 0·013 to 0·014 inch). Fig. **100** shows a very usual shape of core built up of strips of sheet iron which are assembled so as to overlap alternately at their corners. To insulate the strips lightly from one another it is usual to paste a thin layer of paper on one side of each strip. The coils are wound on bobbins or formers ; and it is easy with this construction to slip the coils upon the two vertical limbs when the core has been partially built up.

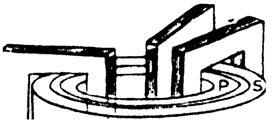
Again, reference to Faraday's ring [**37**, on page 949] will show that in this primitive form the primary coils A were all wound on one side, and the secondary coils B on the other side of the core. But it is found that this arrangement is not satisfactory if the transformer is to give good voltage regulation, as it leads to leakage of magnetic lines between the two windings. It is necessary to keep the two sets of windings as near together as possible, in

103. TRANSFORMER COMPLETE (Ferranti) order that as far as possible *all* the magnetic lines generated by the coils A may thread themselves through the coil B, and vice versâ. So, therefore, it is usual to put half of the A coils on each limb, and half of the B coils on each limb. This is done either by arranging them concentrically, as in **101**, or else by winding them in sections, and then sandwiching the sections of the A coils between those of the B coils, as in **102**. Fig **103** depicts a complete transformer by Ferranti.

Shell Type. As the essential thing in a transformer is that the two coils shall both surround a common core of iron, there are many possible types of construction. The rectangular form described above is commonly spoken of as the *core type*; but there is another frequent form, known as the *shell type* in which a large portion of the iron is outside the copper coils. Figs **104** and **105** belong to the shell type. The laminations appropriate to the former figure are rectangular, with two openings, as in **106**, to admit of the coils, the laminations being themselves built up of strips or sheet stampings which admit of their being put together around the coils. A more recent form is that of Berry, depicted in **107**, in which the coils are cylindrical and concentric, with the cores built up of strips of iron of several widths, in bundles, affording ventilating channels in the interspaces and requiring a minimum section of iron.



104. SIMPLE SHELL TYPE TRANSFORMER



105. SKELETON DIAGRAM OF BERRY TRANSFORMER

106. ARRANGEMENT OF STAMPINGS IN SHELL TYPE FOR OVERLAPPING

Insulation of Transformers. Inasmuch as one side of a transformer is invariably at a high voltage, the question of insulating the coils must be very carefully attended to, especially as, in order to get a good voltage regulation the primary and secondary coils are sandwiched, thus further increasing the proximity between the two sets of coils. Each maker has his own rules in the matter of insulation, but the general practice may be stated as follows. For coils in which wire is used, the wire is doubly and often trebly covered with cotton and varnished with a good hard drying varnish once or twice after it is wound. For coils wound with strips, the strips may be wrapped with cotton tape or even manila paper if the coils are circular, and the whole is dipped in varnish and dried as before.

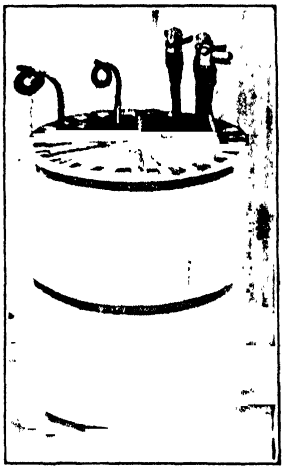
Before being placed on the limbs of the transformer, each coil is separately taped with cotton impregnated with bitumen or rubber in order to insulate the coil as a whole from its neighbour. In cases of extra high voltages, this last is insufficient, and micanite rings and bushes are inserted between the coils, or they are held mechanically apart to a distance of, say, one-eighth or three-sixteenths of an inch by ebonite or hard fibre distance pieces. The leads which bring the primary currents to and from the coils should be extra heavily insulated, and the supports for the terminals should be very substantial.

Heating of Transformers and other Electrical Apparatus. On seeing any piece of electrical apparatus, one is inclined to ask: "How are we to know the limit to its capacity for transforming electrical to mechanical energy, or electrical energy to electrical energy at a different voltage, as the case may be?" Now, in all apparatus used for converting energy a certain loss of useful energy results. This energy appears in the form of heat, and in electrical apparatus the capacity for transformation is limited by the maximum temperature to which we may allow the apparatus to be raised by this spontaneous liberation of heat. The loss of energy in electrical apparatus may be divided under two heads—namely, that in the copper conductors which carry the electricity and that in the iron core which carries the magnetism. The first of these losses may be estimated from the rules already given in the articles beginning on pages 288 and 669, and the second has been commented on in the present article.

The further point, however, for us to notice here is that the copper loss is going on only when the apparatus is loaded, and that its value depends upon the value of the load, while the iron loss is taking place all the time the apparatus is at work, whether it is loaded or not—that is, all the while it is "alive," and is, therefore, independent of the nature of the load.

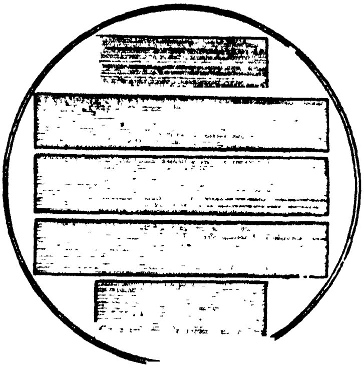
In transformers the proportioning of these losses requires great consideration, for we have the iron losses going on night and day, because the mains must be kept alive, while the copper losses only occur for a few hours in the evening while the load is on. This question will be further considered when we study SYSTEMS OF SUPPLY.

Ventilation of Transformers. In order to increase the capacity of a piece of apparatus of given size, two things are possible—namely, to reduce the losses which take place and to ventilate it more thoroughly, so that the heat is carried away more quickly. We have seen the provisions made for ventilating dynamos, how the armature is built up with spaces to allow a circulation of air through the inmost parts of the machine. With transformers this question is of greater importance. In small sizes, it is sufficient to allow the surrounding air to cool them if ample provision has been made for its free access among the coils and core by suitable spacings. Fig. 108 shows a typical section of a transformer core and the arrangements for circulation of the air between the straight line outline of the core and the inside of the circular core. With larger sizes, however, these arrangements are not sufficient, and it becomes necessary to cool the coils artificially.



107. BERRY'S TRANSFORMER

For this there are two methods at present in vogue. In both of these the transformer is erected in a closed case, and in the first, dry air, free from dust, is blown by fans through the apparatus; while in the second method, the case is filled with a suitable oil which enters into all the corners and nooks, and by its automatic circulation when heated by the waste energy, conducts the heat to the case from the large exposed surface of which it is more easily radiated. In very large sizes even this is not sufficient, and the oil is cooled by leading through it pipes through which cold water is made to circulate.



108 SECTION OF CORE SHOWING PROVISION FOR VENTILATION

The Design of Transformers. There are two main features of a transformer which we may vary, and these are the core and the coils. We may have a large core and only a few turns of wire around it, or vice versâ.

Practice in transformer design has, however, now settled down, and the happy medium which has been evolved between these two factors is now well understood. The size of core may be represented by N, the total flux it has to carry and the size of coil by the ampere-turns at full load, written C_1S_1 or C_2S_2.

Now, the ratio for these two quantities—i.e., $\frac{N}{C_1S_1}$ is known as the *flux factor* (Y), and for ordinary small size transformers (*core type*) cooled by natural draught, the flux factor is between 60 and 70. For artificial cooling, the factor is somewhat higher, varying between 90 and 120 as the voltages become bigger.

The only other formula necessary is that for the electromotive force which may be written

$$E_1 = 4{\cdot}4 \times f \times S_1 \times N \div 10^8,$$

for it is now a matter of simple algebra to deduce the actual values of N and C_1S_1 as follows:

$$C_1S_1 = \sqrt{\frac{Kw \times 10^{11}}{4{\cdot}4 \times f \times Y}}$$

$$\text{and} \quad N = \sqrt{\frac{Kw \times 10^{11} \times Y}{4{\cdot}4 \times f}}$$

As an example, take the case of a 100-kw transformer, oil-cooled, transforming from 5,000 to 500 volts at 50 cycles per second.

A suitable value of Y, the flux factor, is 90, and so, by the equations given, we have

$$C_1S_1 = \sqrt{\frac{100 \times 10^{11}}{4{\cdot}4 \times 50 \times 90}}$$

$$= 22{,}400, \text{ about;}$$

$$\text{and } N = \sqrt{\frac{100 \times 90 \times 10^{11}}{4{\cdot}4 \times 50}}$$

$$= \text{about } 2{,}000{,}000 \text{ lines.}$$

The rest of the design consists simply of making a core large enough to carry the two million lines and to envelop the coils, which last must be of sufficient size to carry the respective currents without overheating.

Note. By an oversight, the formula at the bottom of Column 1 of page 1358 is wrong; the symbol S, meaning number of *spirals*, should be struck out, and the symbol Z, meaning number of *conductors*, should be substituted. Then in the next column, in line 22 from the bottom, after "S will equal 288" insert the words "and Z will equal 576." As a result in the calculation that follows, E will equal 2210 volts.—S P.T.

Continued

Group 1
AGRICULTURE
12

Continued from page 1632

HARVESTING THE CROPS

Methods of Cutting Cereals. Building the Rick. Threshing. Mangel Clamps. Hiring and Wages. Insect and Fungous Pests

By Professor JAMES LONG

THE harvesting of the crops of the farm is, perhaps, the most important feature of the agricultural year. If it is essential to cultivate the land with thoroughness and to sow good seed under the best conditions; it is still more important to save the crops which have been produced by the adoption of those necessary forms of labour. The harvesting of the grain and pulse crops is conducted under very different conditions to those which obtained 50 or even 25 years ago. Hand labour has been largely supplemented, or replaced, by machinery, and it has long been obvious to all concerned that but for machinery the cost involved would have been much more serious, with the result that the farmer's occupation would have become a most precarious one The date of harvest varies—even in this small country—owing to the differences in climate, soil, and temperature. Sometimes, indeed, corn is cut in the South by the third week in July, while we have seen the reaper at work in the North about the middle of September, and in exceptional years, chiefly owing to inappropriate weather, corn crops have remained in the field until November.

The Right Time to Cut. Experience is of great value in enabling the farmer to decide when to commence to cut his crops While he is seldom likely to cut too early, it teaches him that he may cut too late, with the result that the grain is either shed or partially spoiled To wait until wheat or oats are actually ripe is fatal. Wheat, for example, should be cut when the straw has commenced to turn from green to yellow just below the ear, but it must be dry. Difficulty, however, often arises when a large area of grain ripens simultaneously, and when, in consequence, although the farm is well equipped with machinery and men, some must be left

In days now happily passed away, the sickle or the scythe were the only tools employable, the latter especially involving considerable physical labour, from ¾ acre of wheat to 1¼ acres of barley being cut in an average day. The area mown, however, depended to some extent upon whether grass or weeds were grown with the corn. A smaller area was cut with the sickle, which, like the scythe, is now occasionally used—although there are but few men who can do a good day's work with the latter where the corn has been beaten down or twisted by the wind or rain. Hand tools were succeeded by the reaping machine, and the reaper by the self-binder, which, without stoppages or breakages, and with sufficient horse-power, will cut an acre in an hour, or an average of 8 acres in a day, the machinery being kept well oiled and exchange knives kept sharp by an assistant.

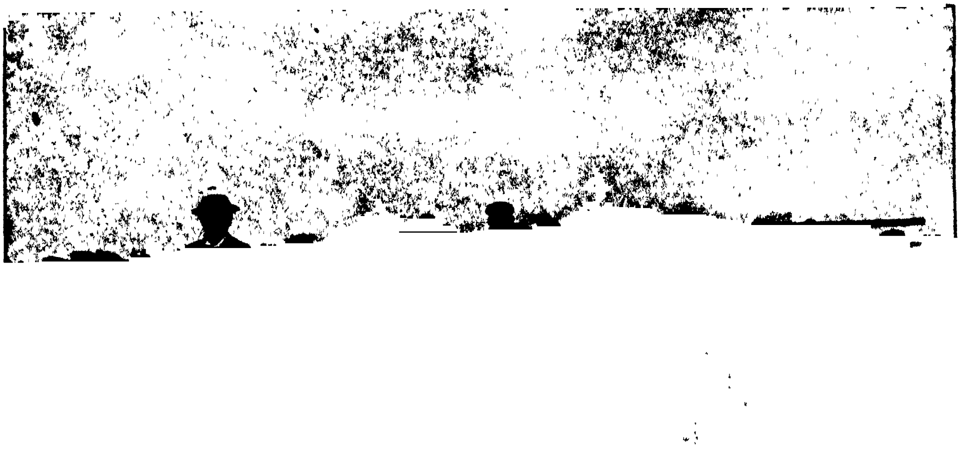
The Advantages of a Binder. The reaper—which cuts the corn, and, by the aid of the sails which revolve over its platform, deposits on the ground at equal distances apart sufficient quantities for tying into sheaves—although a useful machine, is much inferior to the binder. It involves the employment of hands for making bands and tying the corn, whereas the binder ties every sheaf with twine and deposits it ready for stooking. As the corn is cut by the binder it is elevated and packed until sufficient for a sheaf is collected. It is then released, encircled and tied with twine, which is then cut, the sheaf being simultaneously thrown out.

On a well-conducted farm the whole harvest tackle shou'd be overhauled and prepared for work before harvesting commences. The reaper, or binder, which the owner, as well as the driver, should thoroughly well understand, sparing no pains to make themselves proficient in a knowledge of its mechanism, should be in perfect condition, twine purchased, and such spare parts as may be needed owing to wear and breakage procured from the manufacturer; and this especially applies to knife sections, fingers, bolts, rivets, and the cloths which are used for elevating corn on so many machines. The horses should be reliable, and sufficient in number to admit of changes for rest. Judgment is needed, too, in the manner of cutting, for the crop must stand against the machine. If bent, laid, or twisted, the result may be that it is cut too high, leaving much straw on the ground, or that the ears are cut off and wasted, owing to the fact that they cannot be collected with the horse-rake.

Building Stooks. As the sheaves are deposited, they are set up into stooks, four to six a side, wide apart at the bottom, and sloping towards the top, so that the ears of opposing sheaves are close together. In this way damage by rain is minimised It is important, too, that the stooks should be set in the right position, that the wind may pass through them, and thus assist in drying them for carting. Where stooks are carefully built, they will sustain a good deal of rain without harm, but if thoroughly wet, the sheaves may be laid out for drying in the sun. It is sometimes necessary where weeds are plentiful, or where grass or clover sown with the corn has grown with freedom, to untie the sheaves after heavy rain that they may be thoroughly dried before carrying, as wet sheaves in the rick heat and spoil both corn and straw.

Such operations are occasionally necessary from time to time, and thus it is that wet weather involves an expensive harvest. Great judgment is required before carrying, especially in changeable weather. The matter, however, may usually be determined if the farmer goes in advance of his waggons, and personally examines the sheaves by thrusting his hands into the centre beneath the band. Whether carts or waggons are employed is a matter for private decision, although it is usually governed by local custom. The number of waggons and hands employed in carting depend upon the distance of the field from the stack.

Oats. Oats, like wheat, are cut when the straw assumes a yellow tint. On no account must they be left to ripen, for the crop becomes a prey to birds, and quantities of grain are shed Oats are usually spoiled if they are stacked in a damp condition. How far the damage has proceeded is too well realised when the grain from a crop which was carried damp is employed for seed Dampness is followed by mould, a musty smell, and an unnatural colour. As oats are more liable to damage than wheat, they are usually kept longer in the field

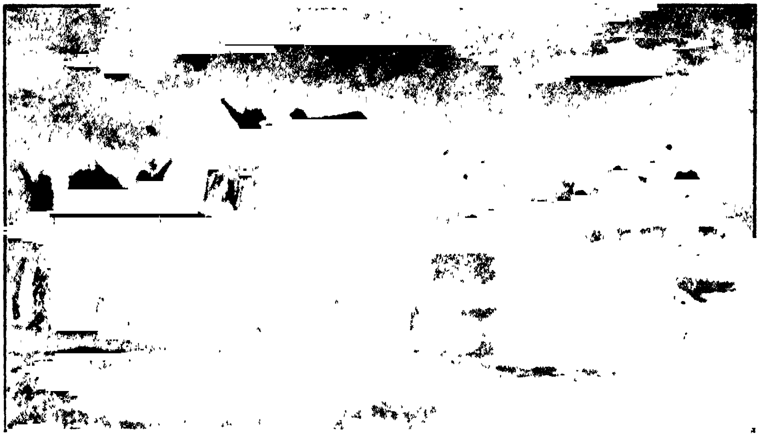


A MOTOR DRAWING THE HARVESTER

Barley. Barley, contrary to wheat and oats, should be practically dead ripe, with the ear hanging as though the straw had been fractured at its base, and the grain hard and wrinkled. It is usual to allow a barley crop, when cut, to lie loose on the ground, for in this way it can be carted earlier, while it is sometimes improved in quality if there is sun by day and dew at night. The process of turning the crop while in the swathe is in such a case followed by a more uniform colour and general mellowness. For the reason that tying is seldom essential, and because the straw is shorter and lighter, barley is often cut with the scythe, especially as fewer ears are lost Barley, too, as a rule, though shorter, stands less erect before the reaper, with the result that the ear is often removed by the knives. Grasses and clover, lucerne and sainfoin, are often sown with a barley crop; hence, especially in wet seasons, a considerable quantity of green material, or it may be of weeds, is present, for which reason tying becomes next to impossible. A high-priced malting sample must be well coloured, and this is largely prevented by tying, while the risk involved in stacking sheaves largely composed of partially dried grass may be considerable, for, if heated in the rick, barley becomes useless to the maltster.

Where a barley crop is clean and dry, and the weather all that can be desired, the binder is sometimes permissible, but the chief advantages are expedition in carting and threshing. It is most essential to stack barley in an absolutely dry condition, leaving nothing to chance, and covering the rick with thatch at the very first opportunity. A small percentage of wet sheaves will always spoil a malting sample, hence, from first to last, damp sheaves should be excluded. In some parts of these islands where the rainfall is heavy, it is customary to build a series of very small ricks rather than a few large ones, for the reason that damage by heating and mould is minimised.

Beans. Beans are cut with the reaper, the scythe, or the hook, or under certain disadvantageous conditions they are pulled by hand. The bean crop is ready for harvesting when the leaf drops, although the corn is still soft. Owing to the stouter character of the haulm, or straw, beans are often cut in damp weather, tied, stooked, and left in the field until quite fit for carting. When well dried, however, the crop becomes brittle, and unless great care is exercised a proportion of the corn will be shed and lost. Beans require plenty of weathering before stacking, although, if sufficiently dry, they may be successfully carried during damp weather, such as that which would be unsuitable for cereal crops. As bean straw is a valuable fodder, however, it is wise to make every effort to prevent the slightest damage.



THRESHING AND STACKING

Peas. Peas are usually cut with a hook or sickle, and laid in heaps, which are turned two or three times, as may be found necessary, especially if the weather is damp. The pea crop should never remain to ripen before harvesting; the pods become brittle and are liable to open, and when the pulse is hard, to shed it. Peas must be quite dry before carrying, otherwise they heat and become mouldy, when the very valuable haulm, or straw, is diminished in value as a food for stock. When the pea crop—both pods and straw—assumes a yellowish colour, it is ready for the sickle.

Building the Rick. In the building of corn ricks, it is most essential that the corn should be protected against vermin. For this reason, staddles from two to three feet off the ground are of great value, especially as they permit the free circulation of air beneath. Where these are not employed, the rick bottom should be made by the aid of faggots, and plenty of them. Where the corn is in sheaves, the centre of the rick should be kept the highest, and the sheaves laid sloping, with the ear ends upwards and towards the middle. The object is that, if rain enters the rick, it will be shot off towards the outside, leaving the grain as little damaged as possible. Allowance must in all cases be made for settlement, especially before the rick is thatched.

Corn ricks are usually round, with the bottom or butt ends of the sheaves at the outside, so that the corn, being within, cannot be stolen by birds. In building, the diameter of a rick increases from the bottom to the eaves, and diminishes from the eaves to the point at the top, this portion of the roof being covered with extra thatch. Some farmers pare the outsides of the rick from the eaves downwards, not only with the object of making it look more tidy and presentable, but of giving it compactness and affording protection. The body of the rick, like the roof, should be even on all sides. The roof, in particular, must be well finished off before thatching, otherwise, with settlement, hollow places will form, which may admit rain and result in damage. Ricks are usually thatched by the square of 100 ft., at a cost of from 1s. to 1s. 3d. per square, the farmer finding the straw, the stakes, and the twine, where thatching twine is employed.

Threshing. Threshing is more frequently a winter operation, and where a threshing machine does not form part of the equipment of a farm, it is usual to hire it, payment being made either by the hour or day, the bushel or the sack of corn threshed. Custom, however, usually rules this condition. The threshing machine owner provides the driver of the engine, and usually one or two men; but in practice a gang of men, whose services are more or less necessary, in addition to the ordinary labour of the farm, usually follow the machine. These men are paid by time, and, disagreeable as the custom is, supplied with beer. The hands required to conduct the operation of threshing, in addition to the driver and feeder, are for carting water for the engine, removing the chaff and cavings (a coarse by-produce between the chaff and the straw), cutting the sheaf-string, bagging and carting the corn. Others will be needed on the corn rick and the straw stack, and for attending to the elevator by which the straw is raised, if such is used.

Before the engine arrives, coal must be purchased and deposited in a handy spot. When it has been removed, the refuse, and especially the weed-seeds which have been rejected by the machine, should be burned. In some cases the cavings and chaff are left for salvage until a more convenient day, with the result that both are often spoiled and even destroyed by rain. This involves great waste and loss, for both are useful as food, and no pains should be spared to secure them while sweet and dry. The corn, which is usually carted to a secure and dry granary, may have to remain for some time until it is sold. In such a case it is usually essential to turn it with a shovel from time to time, to keep it dry and sweet.

Market Samples. Before sampling for market, and especially, too, before delivery, the corn should be dressed by the winnowing machine, which removes all foreign material and any chaff still remaining, together with the imperfect and broken grains, which are likely to spoil the sample. Two or three dressings, in spite of the time involved, may be essential in order to obtain a first-rate market sample.

Before offering a parcel of grain to a purchaser, it is well to carefully fill a bushel measure, strike it clean, and weigh it, in order that the buyer may be informed as to its natural weight. A market sample should be as perfect as possible, but honest, and taken from bulk, for the corn delivered will have to correspond with it. Samples may be offered to responsible corn-dealers or millers, or to merchants in general on the Exchange. As it will be necessary to name a price when an offer is made, the opinions and experience of other growers may be obtained, and especially those who have already effected sales. When a fair price is offered by a responsible buyer, it is well to sell in times like the present, for delay, instead of bringing better prices, is more often accompanied by a fall. The retention of corn, whether in the rick or the granary, involves additional labour and loss by vermin or birds, or both.

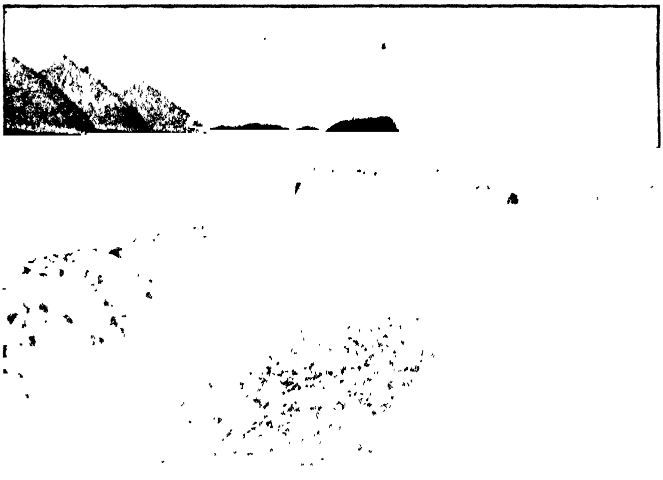
Potatoes. Potatoes, still harvested on a small scale by digging with the fork, are usually lifted with a potato plough or a modern harvester, one or two patterns of which both sort and bag the tubers at one operation. The earlier potatoes are harvested when sufficiently large, and when good prices are commanded, but the main crop must not be lifted until the skin is ripe and adheres to the potato without peeling when rubbed. Potatoes, when dug, are usually left on the ground to dry and mellow before bagging. Care must be exercised in sorting the ware (marketable) and the chats (the small), any unmarketable potatoes being kept apart, while those which are diseased must be entirely excluded.

Potatoes are preserved by clamping in a manner similar to that adopted with mangels and swedes. The bed should be dry and trenched around the outside, the potatoes packed and piled upon clean, sweet straw, heavily covered with the same material, and subsequently with at least six inches of dry soil.

Where disease is suspected, or is actually existing, care must be taken to remove tainted tubers. Some growers sprinkle the sound tubers in such a case with lime, to prevent further extension of the disease, but the practice had better be adopted on a small scale as an experiment, until it is ascertained whether it proves successful. The potato clamp should be well ventilated and examined two or three times at least during the winter, if the crop is kept so long, so that in case trouble is discovered a sale may at once be effected.

Mangels. Mangels are harvested before the arrival of frost, which they cannot withstand. They are pulled, and the tops twisted off by hand, cutting being objectionable. The bulbs are left in rows or heaps on the ground to dry, and, where frost is liable to follow, covered with the leaves until they are carted. The leaves are subsequently left on the ground and ploughed into the soil, in which they act as manure. Mangels are preserved in heaps or clamps, and protected by the aid of straw and soil, as we have suggested in the case of potatoes.

When *swedes* are lifted, the tops should be cut off, but not the roots, common as the plan is. Although in the milder districts they are frequently left in the field, and consumed by sheep in early spring, swedes are always liable to be destroyed by heavy frosts. They may be pulled and laid in rows, and covered with a little soil by the plough, or laid in small heaps in the field, and covered with soil with the spade, or, lastly, they may be carted, like mangels, and clamped.



THE MANGEL CLAMP READY FOR COVERING

Observe the trim form of the corn stacks

Clamps should always be made in well-selected positions, where frost and rain will be least felt. The roots should be well matured and well protected with straw and soil, but it is important that they should be weathered in the field before carting, this plan hardening or toughening the skins. Diseased roots should be invariably rejected.

A *clamp* is triangular in form; its width at the base should not exceed 7 ft., and the bulbs should be piled to a height not exceeding 4 ft. to 5 ft. Occasional openings should be left in the ridge for ventilation, these being filled with straw. In some districts, however, mangels are preserved in heaps of very considerable size near the cattle houses, without regard to width or height; but no plan is more successful than that which has been described.

Carrots are preserved in the same way as swedes, while *Parsnips*, which are hardier, may be left in the ground until required, although it is wiser to dig and clamp them in order that the ground may be ploughed for a future crop.

Harvest Labourers. Harvesting in general demands extra labour on the farm. Large numbers of excellent Irish workmen annually leave their homes for England and Scotland to assist in the work, and, like the regularly employed men, obtain a higher rate of pay, which is necessarily demanded at such a period. Payment is made for harvesting either by the month, the week, or the day. The last is applicable only to temporary hands. Sometimes, however, the men are paid by the job, 10s. to 12s. per acre not being uncommon. The terms asked are sometimes regulated by custom, the same price being paid from year to year, at other times by competition. The farmer is guided by the terms prevalent among his neighbours; the men by those which have been made by the labourers on adjoining farms. Liberal payment usually secures reliable men and good work; but no stipulation should be made for the provision of unlimited beer, which frequently causes outbreaks of temper, quarrels, and disputes, not only between master and men, but between the men themselves. It is doubly economical to provide harvest men with coffee, tea, cocoa, liberal supplies of milk, or a drink made by the aid of oatmeal, sugar, and lemon-juice, if they are agreeable to accept it, rather than to supply beer as part of the money bargain.

INSECT PESTS

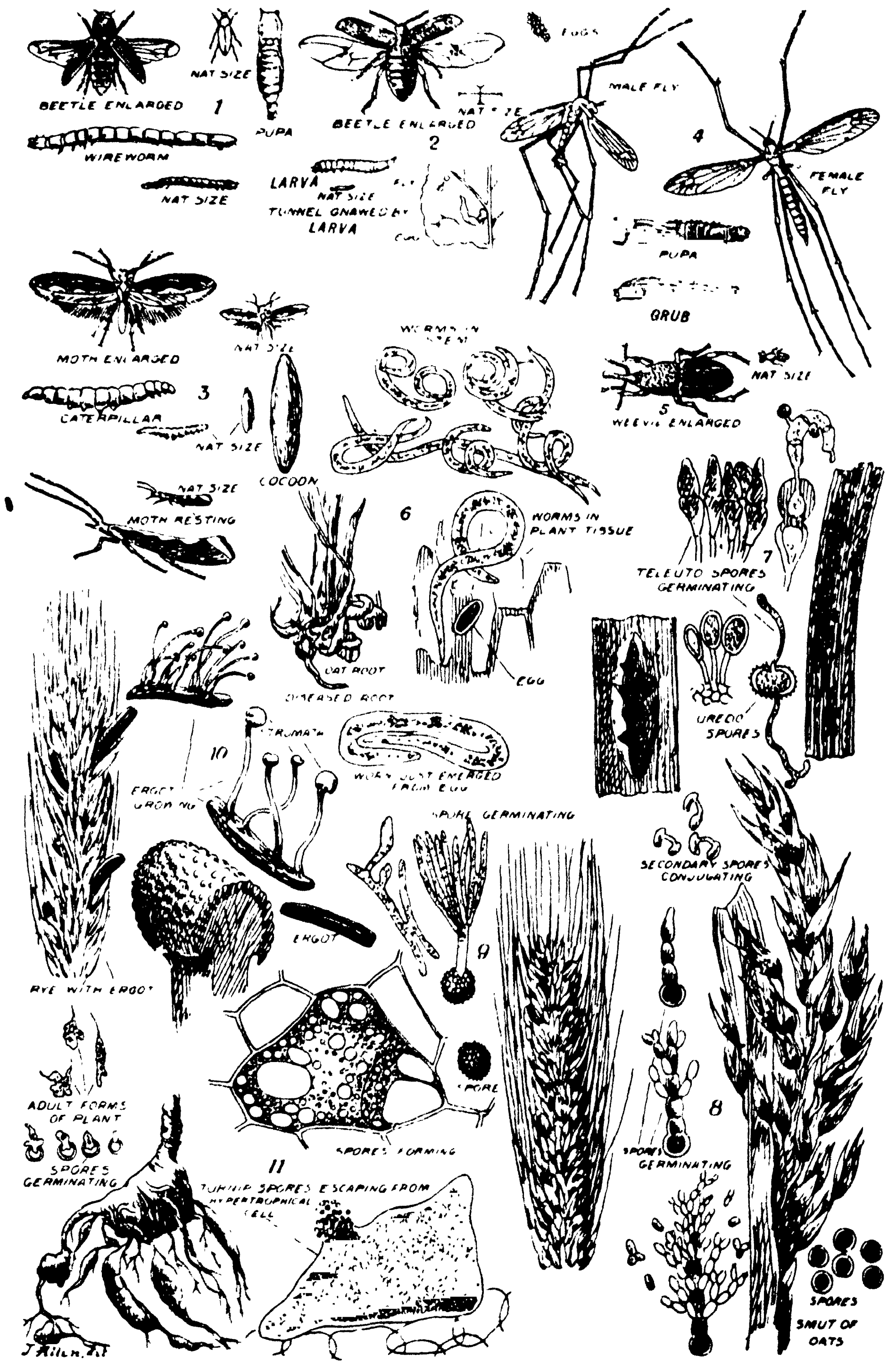
Scientifically speaking, an insect is a member of the great class Insecta. Insects, as a rule, undergo a distinct *metamorphosis*, or series of changes, between the egg stage and maturity. The egg produces a caterpillar, for instance, which becomes a chrysalis, and this changes into a butterfly or moth. For our present purpose, however, it will be useful to describe some creatures which are not, correctly speaking, insects—*e.g.*, the stem-eelworm.

General Principles for Dealing with Insect Pests. In attacking insect pests it may be observed that some insects are most easily dealt with at a particular stage of their life history, as the larva, pupa, imago (mature insect), or egg; while at a special stage, also, they are most hurtful to crops. For example, neither butterflies nor moths are harmful in themselves, but they lay eggs, and it is invariably the caterpillars which do the damage. In the case of beetles, both the mature insects and the larvæ may be harmful, while greenflies attack their host-plants all through life.

Some insects, again, such as caterpillars, chafer larvæ, have biting mouths, and may therefore be directly destroyed by dressing their host-plant with poison which is consumed with the food of the larvæ. Others—*e.g.*, greenflies—have a piercing and sucking mouth, and cannot be poisoned in this way. The former devour their host-plant bodily; the latter suck up the juices after piercing the plant tissue. Creatures like greenflies are best dealt with by employing such materials as soft-soap and paraffin, which, used in the form of an "emulsion" sprayed over the pests, may be said to glue them together, stopping up their breathing pores, and so destroying them. All insect pests should be attacked at the weakest stage of their life history.

An Effective Weapon. Apart from these remedies, the farmer has an effective weapon at hand if he does but know it and use it aright. We refer to *good cultivation*, which is said by Somerville to be the "best protection that the farmer or gardener can offer his crops against the ravages of insects." Wherever crops are allowed to become weak, are insufficiently nourished, or foul with weeds, there insect pests are more likely to abound, and their attacks to become more serious. Many insects attack plants of a special order—*e.g.*, the turnip flea-beetle, which lives on plants of the order *Cruciferæ*. If therefore, such weeds as charlock (*Sinapis arvensis*), Jack-by-the-hedge, or garlic-mustard (*Sisymbrium alliaria*) are plentiful, the flea-beetle is encouraged. Good cultivation, including tillage of all kinds, the use of artificial manures to enable crops to grow rapidly away from attack in cases where the young plants are infested, seasonable sowing of good seed in the right situation—all these will assist in avoiding extensive infestation better than any remedial measures in suppressing the enemy when once it has obtained a firm footing. Hedges and ditches should everywhere be kept clean, and free from weeds. Good cultivation *in autumn* is especially useful, as many hibernating insects are then turned up, and devoured by birds, or killed by frost. Insectivorous birds should be encouraged.

The Wireworm. This creature, which every farmer recognises as a dreaded pest, is the larva of the "click," or "skip-jack" beetle, of which there are several species, notably *Agriotes lineatus* [1]. The wireworm attacks nearly every kind of root, and may be found almost embedded in potato tubers, in carrots, and in the roots and stems of other plants, particularly cereals which are just beneath the surface of the ground. Whole fields of corn are frequently destroyed by the pest, especially after pasture and clover leys have been broken up. Wireworms [1] are slender but "wiry" grubs, of perhaps the thickness of a knitting-needle. They are upwards of an inch long, yellowish-brown in colour, with six legs near the head end, and strong jaws, with which they destroy and devour their host-plants.



INSECT AND FUNGOUS PESTS OF THE FARM

1. Click Beetle and Wireworm. 2. Turnip Flea-beetle, or Turnip "Fly." 3. Diamond-back Moth. 4. Daddy Longlegs, or Crane Fly. 5. Corn, or Granary, Weevil. 6. Stem-eelworm. 7. Rust of Wheat. 8. Smut of Oats (Ustilago avenæ). 9. Bunt, or Stinking Smut of Wheat (Tilletia tritica). 10. Ergot of Rye. 11. Finger-and-toe in Turnips

Rolling corn crops (with a ring roller), the use of stimulating manures if the crop is attacked, trapping the wireworms with pieces of beetroot (failing this, potatoes), have all been suggested as remedies, and are all undoubtedly useful. Drilling acid forms of manures, such as superphosphate, with the crop is also believed to be useful, as it prevents the pests working in the rows. All *weeds* should be suppressed.

Turnip Flea-beetles, or "Fly." These tiny beetles (*Phyllotreta nemorum*), about one-tenth of an inch in length, are among the farmer's worst enemies. The mature beetles devour the tender first leaves of turnips, radishes, mustard, cabbages, and allied plants, giving them the appearance of having been riddled with small shot; the larvæ mine the leaves [2] and feed on the soft tissues. Whole districts are sometimes almost cleared of turnip crops, and three successive sowings have been alike ruined. The beetles [2] are blackish in colour, and have a broad, yellow stripe down each wing-case, showing, when at rest, two stripes down the back. For prevention and remedy: Good cultivation is essential, with no clods under which the beetles can shelter; hastening on growth by means of artificial fertilisers; suppressing cruciferous weeds; spraying the crop with paraffin by distributing it in the form of a very fine mist (using a "spraying machine") to make the plants distasteful to the beetles. As fresh generations are rapidly produced, immediate action should be taken in case of attack.

Diamond-back Moth. In 1837, 1851, 1883, and 1888 this moth (*Plutella maculipennis*) was very injurious to the turnip crops, while in 1891 there was so serious an infestation in the Eastern Counties, from Kent to Aberdeenshire, that the Board of Agriculture made an inquiry into the circumstances and extent of the attack. During 1904, also, the pest was prevalent. It is not the moths, but the hordes of caterpillars [3] which directly do the damage, these latter congregating on the plants and devouring every particle of the soft tissues of the leaves. The moth is two-thirds of an inch in expanse of wing, and when at rest certain marks on the wing-margins assume a diamond-shaped form along the back [3]. It is believed that the best remedy in case of attack is to dress the infested plants thoroughly with a mixture of one part of lime to three parts of soot. Forcing manures to help the plants are useful. The caterpillars may be brushed off, and many destroyed, by means of boughs tied to a horse-hoe.

The Cockchafer (*Melolontha vulgaris*). This is a beetle which does much harm to crops when in the larval stage; it also does considerable damage in the mature state. This pest is more fully dealt with under FORESTRY.

Daddy Longlegs. This well known and curious insect [4], termed also the crane fly, occurs in two common species (*Tipula oleracea* and *T. paludosa*). It is harmless in its mature form, but in the grub stage it is exceedingly hurtful. The grubs [4] are about 1 in. in length, brownish in colour, and bear powerful biting jaws. They have no legs, but move freely, and have a much-wrinkled, leathery skin. To grass they are exceptionally harmful, sometimes destroying large tracts, but they attack all classes of farm crops indiscriminately, devouring the roots. Prevention and remedy: *Good cultivation*, clean ditches and hedges, early and thorough ploughing of grass and clover, dressing with artificial manures to hurry crops on, thorough harrowing and rolling of spring corn in April or May, and hoeing of root crops. Birds help considerably by devouring both grubs and flies.

The Corn, or Granary, Weevil. This pest (*Calandra granaria*) is frequently very destructive to stored grain. The grubs are exceptional, in that they have no legs. Eggs are deposited singly in holes bored in cereal grain, on which the resulting grubs feed, afterwards pupating and maturing *in situ*. The mature weevil [5] is about one-seventh of an inch in length. McConnell recommends "frequent turning of the grain; clean, whitewashed granary; winnowing out and destroying the light, affected grains"; while Somerville points out that "a sheep's skin laid on a heap of infested grain will attract many beetles, which may then be shaken into water."

The Stem-eelworm (*Tylenchus devastatrix*). Eelworms of one species or another attack a great variety of cultivated plants, among these being wheat, oats, beet, potatoes, clover, lucerne, and hops, as well as market garden crops. "Tulip-root" in wheat and oats is caused by *T. devastatrix* [6], while the same species also gives rise to one of the conditions termed "sickness" in clovers. On the Continent, especially in Germany, considerable loss is due to this pest. As the name implies, the creatures are eel-like in appearance, while they are microscopically small, according to Ritzema Bos being usually between one-fifteenth and one-thirtieth of an inch in length. As both eggs and young worms retain their vitality for a considerable period, even when in a perfectly dry condition, the pest may be easily spread. To render an attack less likely, different crops should be as widely separated in the rotation as possible; thorough cultivation, with deep ploughing, should be practised; and Ritzema Bos recommends "abundant manuring, especially with sulphates of potash, ammonia, and iron."

FUNGOUS PESTS

Fungi [see page 166] may be described as *saprophytic*, or *parasitic* forms of plant life which contain no chlorophyll, or green colouring matter. An example of a saprophytic fungus, or one which lives on dead or decaying organic matter, is the common mushroom; on the other hand, the chief fungous diseases of crops are parasitic, passing their lives on *living* plants.

Like insect pests, injurious fungi—for not all fungi are injurious—should be attacked at the weakest point in their life cycle. Many pass their first stages on weeds, afterwards infesting cultivated crops; all weeds, therefore, should be suppressed. Most plants, both in the case of insect and fungoid infestation, are most liable to attack when weak and backward, but healthy, strong plants resist attack. With fungi, then, it will be found that "good farming" is almost as effective in preventing infestation as in the case of insects, and manuring will much aid the crops in their struggles towards maturity.

Rust of Wheat. The black rust of wheat (*Puccinia graminis*) is widely distributed, and although found on other cereals, is chiefly harmful to wheat. Its life history is somewhat involved, the earliest form occurring in spring on the barberry [**226**, page 1373], from which mature spores, or seeds, called *æcidiospores*, pass to wheat and grass plants, where they germinate and produce groups of fresh spores (*uredospores*), which are of a rusty hue, and occur in streaks [**7**] on the wheat plants. Towards autumn yet other spores are produced, and the streaky blotches, or pustules, become almost black in colour, this being the *mildew* form of the disease, new spores (*teleutospores*) carrying the fungus over the winter. The damage consists in the fact that the wheat plants are robbed of their nutriment, great loss in quality and quantity of the grain resulting. The early rust spores (*uredospores*) alone are sufficient to perpetuate the disease. All grasses along hedges and ditches should be kept down, only perfectly clean seed should be used, and mildewed straw should be burned. Draining and liming are sometimes useful.

Smut and Bunt. The first of these fungous diseases (Smut, *Ustilago*) attacks all kinds of cereals [**8**], the grain being the part affected. The dusty black spores are quite conspicuous on the ears, and are easily shaken off. Infection occurs at the time of sowing, the spores, of which some 4,000 are required to measure an inch, being invisible on the seed grain. The loss in the past due to *ustilago* has been very great. The second fungus (Bunt, *Tilletia*) differs from *ustilago*, in that the spores remain hidden in the grain, practically every grain in the ear being diseased. It is, therefore, not easily detected. When the grain is rubbed the spores escape, and emit a disagreeable odour. Wheat is chiefly attacked [**9**].

For both smut and bunt the chief preventive measure consists in treating the seeds before sowing. Wheat may be "steeped" in a half per cent. solution (½ lb. in 10 gals. of water) of copper sulphate (bluestone) for about 12 hours; or dipped into hot water at a temperature of 130-135° F. for five minutes. For barley and oats the hot-water system should be employed, or the grain may be soaked in a solution of formalin (1 pint of 40 per cent. formalin in 36 gals. of water) for 10 minutes.

Ergot of Rye. This disease (*Claviceps purpurea*) not only causes great loss on account of its effect on rye, but it also occurs on wild grasses, and, under certain conditions, is said to be the occasional cause of simple abortion in cattle. It also infests other cereals. It attacks the bloom, the grain being replaced by a hard, somewhat curved, horn-like mass, known as ergot [**10**]. From this peculiarity the disease is easily recognisable. To prevent future attack, all the spur-like processes (ergot—Fr. for "cock-spur") should be gathered and burned, together with those obtained in cleaning the grain.

Finger-and-toe in Turnips. This widespread disease, which has been the cause of immense loss, is extremely infectious, and attacks turnips, swedes, cabbages, and similar plants [**11**]. Its scientific name is *Plasmodiophora brassicæ*, while it is also commonly termed Anbury and Club-Root. The fungus causing the malformations and decay of the roots ("Fingers-and-toes" being an appropriate name) may remain dormant in the soil for a considerable period, and is readily spread by mechanical means. All weeds of the same type or order as turnips—*e.g.*, charlock and garlic-mustard—should be rigorously suppressed, and all affected plants burned. A second turnip or similar crop should not be taken for some time on infected land—once only in eight years if possible. Phosphates, manures containing acids, and sulphates are said to favour the disease. The chief agent by which the disease is combated is burnt lime in moderately large quantities, and it is found that finger-and-toe is by no means so prevalent where soil contains a high percentage of lime.

Potato Disease. Although there are several other fungous pests which infest the potato, none are of such vast economical importance as potato disease (*Phytophthora infestans*). It was well remarked by Professor Marshall Ward, in writing of this disease, that "since the malady in question has at various times attained such virulence that large areas of population have been seriously affected by the effects of its ravages, we have weighty reasons for regarding it as *the* potato disease." It is not so prevalent as formerly, largely owing to the war waged against it during the past two decades. The leaves and haulm blacken, and if the attack is severe the haulm also becomes decayed very quickly, while there is also present a very disagreeable smell. Tubers, when lifted, may be in all stages of decay. To combat the disease, the haulm may be turned down and buried by high moulding; all diseased haulm should be burned when the crop is raised; none but perfectly clean tubers should be used for "seed"; frequent change of seed should be resorted to; and the growing crop may be early sprayed with Bordeaux mixture—that is, a two per cent. solution of sulphate of copper (bluestone) containing one per cent. of fresh quicklime (2 lb. bluestone, 1 lb. quicklime, 10 gals. water).

For other farm pests the student may refer to the following works:

"Manual of Injurious Insects," E. A. Ormerod; "Farm and Garden Insects," W. Somerville; "Agricultural Zoology," Ritzema Bos (Translation by J. R. Ainsworth Davis); "Agricultural Zoology," F. V. Theobald; "Diseases of Plants," H. Marshall Ward; "Text-book of Plant Diseases," G. Massee; various leaflets issued by the Board of Agriculture and Fisheries. The student should also study pages 1372 and 1373 in the NATURAL HISTORY section.

Continued

Continued from page 1516

THE FALL OF JULIUS CÆSAR

Cæsar as Reformer. Brutus and Cassius. Death of Cæsar. The Popularity of Octavius. The Story of Antony and Cleopatra

By JUSTIN McCARTHY

CÆSAR'S rule as a reformer was not destined to last long. Every earnest reformer has to encounter enemies who regard his projects as revolutionary and dangerous to the community, even when they are not inspired by a personal hatred of the man whose policy threatens their position and power. It was Cæsar's misfortune to make enemies thus among some high-minded and unselfish men, who sincerely believed that his policy was the subversion of the Republic. These were the most dangerous enemies whom Cæsar had to encounter. The self-seekers, the men who were concerned only to maintain their own rank, their own privileges, and their own extorted shares of the public funds, might have been kept in order by the overwhelming force of public opinion and the strength of the majority. But among the sincere and patriotic Republicans of Rome there were many men of high character who had become fanatical in their detestation of any efforts to set up an imperial rule, and with whom the devotion to their own political principles had become a positive superstition. Such men have appeared and re-appeared in history during all revolutionary times; men with whom the act of tyrannicide has been contemplated as a religious duty.

Brutus and Cassius. Some such men were now active in the public life of Rome. One of these was Marcus Junius Brutus. He was the nephew of Cato, and had been trained up to a life of culture and high principles. During the civil war he had taken the side of Pompey, but after the battle of Pharsalia, Cæsar, whose captive he had become, treated him not only with mercy, but with generosity. He saw that the young man had in him high capacity and many noble qualities, and gave him important offices in the State. Brutus was surrounded by men who constantly impressed on him the idea that Cæsar's purpose was to make himself the Emperor of Rome. The most prominent of these was the Cassius whom history and Shakespeare have consigned to immortal obloquy. Cassius had distinguished himself as a soldier, and had held high office in the Roman State. He joined the party of Pompey in the civil war, and after the defeat of Pompey at Pharsalia, had to surrender to the conqueror. Cæsar treated his captive with all that clemency which belonged to his nature. He not only released Cassius from punishment of any kind, but afterwards enabled him to hold high office in the State.

Cassius, however, continued to be Cæsar's mortal enemy. Whether there was any secret cause or excuse for this implacable hatred, the world has never known; but it does not seem to have been the result merely of fanatical devotion to the Republican cause. Cassius was a man of varied ability and persuasive power, and he applied himself with only too much success to the task of convincing Brutus that nothing but the death of Cæsar could save Rome from the tyranny of a self-created and despotic Emperor.

The Death of Cæsar. Cassius formed a conspiracy among some of the supporters of the aristocratic party to save the Republic from the tyrant by the weapon of the patriotic assassin. Brutus yielded to persuasion, and became one of the conspirators. From all that is known of him we may assume that he believed himself endowed with a right to decree and to help in executing the death-warrant of his friend and patron. Even in the most modern days we find that men of otherwise stainless character have become possessed with a fanaticism which justifies even murder in the maintenance of some principle to which they are willing to sacrifice every article of morality and religion.

The plot of the conspirators became known to some of those around Cæsar, who received friendly warnings of the danger threatening him; but, with his characteristic indifference to all risks, he went his way. On the 15th of March, in the year 44 B.C., Cæsar went to the Senate House. On his appearance, one of the conspirators presented him with a petition, while others pressed closely around him, as if anxious to know his answer.

But Cæsar suddenly became conscious of the danger threatening him, and sprang to his feet as if preparing for self-defence. Then the dagger of Casca struck the first blow, while the other conspirators drew their swords and struck at him. Cæsar had drawn his own sword—the sword which had gleamed for victory on so many a battlefield—and strove to defend himself, until he saw that Brutus, too, the friend whom he had loved and protected, was approaching him with naked weapon. "Then," in the words of Shakespeare, "burst his mighty heart." He uttered in Greek the memorable words, "Thou, too, child," drew his robe over his face, and sank pierced with many wounds, "even at the base of Pompey's statue." So passed out of life one of the greatest men known to the world's history—perhaps the greatest mortal who has ever borne a part in that history.

A Mistaken Policy. The death of Cæsar did not bring about that victory for Republicanism for which men like Marcus Brutus were willing to sacrifice alike their friends and their moral code. Cæsar had left

ANTONY'S ORATION OVER THE DEAD BODY OF JULIUS CÆSAR

[illegible]

no son, but had adopted as his heir his grand-nephew Octavius, who was soon to hold that imperial power to avert which Julius Cæsar had been put to death. The regicide party, who fondly hoped that the sacrifice of Cæsar would secure the triumph of the Republic, found themselves confronted by wholly unexpected obstacles. The people of Rome could only think, at such a time, of the great deeds done by Cæsar, of the lustre he had cast upon his country, and the fact that in the civil war he had fought against the domination of the aristocracy and in defence of the popular cause.

The Senate met, and its members became inspired with the vain hope that civil war could be avoided by dealing mercifully with those who had killed Cæsar, and assuming that they had been acting on public and patriotic impulses.

Public Feeling. It was agreed that an amnesty should be issued for the murderers. But the events quickly showed how entirely the popular feeling was misunderstood, and how great was the majority of those who condemned the murder, and desired to avenge it on its authors. Mark Antony came at once to the front and showed most timely energy, and a thorough appreciation of the whole state of things. He took possession of Cæsar's house and papers, and claimed to stand as the representative of the dead dictator. Among these papers was Cæsar's will, in which he declared that his great-nephew Octavius was to be his heir. He left his gardens by the side of the Tiber as a public possession for the Roman people, and also a large sum of money to be distributed among poor and deserving citizens of Rome. Mark Antony was entrusted with the duty of delivering the funeral oration on the occasion of Cæsar's burial, and it can easily be imagined what an effect he produced when he told of the bequests which Cæsar had made to his people.

The Senate did not feel that they could venture to do anything except confirm the will of Cæsar, while the Roman population flamed out in such anger against the conspirators that Brutus, Cassius, and their associates saw no chance of safety but in immediate flight. Antony had it all his own way for a time. But although he had assumed the position of Cæsar's representative, and made a splendid show of Cæsar's munificent spirit to the Roman people, he was not inclined to lend his aid towards the carrying-out of that part of Cæsar's will which made Octavius his heir. We are only left to conjecture whether Antony was influenced in his feelings towards Octavius by some personal ambition, some hope that it might be within his power to rise to the position which the dead Cæsar had filled. But whatever his motive, it is certain that he opposed the claim of Octavius to become the heir of Cæsar's fortune.

Popularity of Octavius. Octavius had by this time returned to Rome from the camp where he had been in military training. He was now only eighteen years of age, and he at once assumed the position of recognised heir to Cæsar's fortune and to the name of Cæsar as well. While still endeavouring to obtain the fortune bequeathed to him, he spent large sums of his own in paying up as much as he could of the legacies which Cæsar had bequeathed to the citizens of Rome. He became at once immensely popular throughout Rome, and thus formed from the very beginning a powerful party to support him in all his claims.

A Power in the State. Cicero, the great orator, was at this time a power alike in the Senate and in the State. He had taken no part in the conspiracy against Julius Cæsar, but he had shown no inclination to press measures of punishment against the conspirators; and he was known to be an adherent of the Republican principle. He felt, and freely expressed, his strong hostility to Antony, and delivered a series of powerful speeches against him, which were called at the time "Philippics," a name adopted from the famous orations of Demosthenes against Philip of Macedon.

Cicero did his best to prevent the establishment of a thoroughly autocratic power and dynasty in Rome, but his efforts proved wholly unsuccessful. One reason for this failure was unquestionably that the people had grown utterly weary of sudden changes in the constitution of the State, and of the struggles of faction against faction. Rome had come into that condition in which France was after her great Revolution, when it seemed to the majority that nothing could save the State but the imperial rule of Napoleon. Antony had, in the meantime, led an army into Cisalpine Gaul. Cicero and the young Octavius prevailed upon the Senate to regard this as an act of war, and an army was sent out to oppose him. Antony was defeated in the first instance, and the result was that Octavius demanded the highest military position in the State.

Here again, of course, came a serious crisis. Cicero began to regard Octavius as one who was trying to obtain the control of the military force in order to realise his ambition to become ruler of the State. The Senate endeavoured to pass over, or to postpone his claim, but Octavius was now as popular with the troops, who still adored the name of Cæsar, as with the great mass of the Roman citizens. The Senate, whether they would or not, had to give him the Consulship and the military command.

Compulsory Terms. Antony came to terms after a while, but only to terms of a temporary order. Octavius, Antony, and Lepidus agreed upon an arrangement by which they were to be appointed commissioners for the reorganisation of the State; and the Senate could see no way out of the difficulty other than by sanctioning and ratifying this new and startling triumvirate. Then followed the usual course belonging to such sudden changes in the rule of a State, a severe proscription directed against all who had opposed the newly self-constituted authorities. The name of Cicero held an early place in the list of the proscribed. Cicero was then in his sixty-third year—the time was within some forty-three years of our Christian Era.

The Death of Cicero. Cicero fled from Rome to his villa in the country, and thither he was pursued by a body of Antony's soldiers, who captured him while he was borne recumbent in feeble health on an invalid's litter. It may be said that no part of Cicero's conduct in life became him like to the leaving of it. He had a number of slaves with him who were ready and willing to fight to the last drop of their blood for the master they loved. Cicero knew well that nothing could come of such a struggle but the slaughter of his devoted slaves, and he commanded them earnestly to attempt no resistance. He offered his neck to the weapons of his captors, and was executed as if he had been a public criminal. His head and hands were cut off, and by the orders of Antony were carried to Rome and there displayed in one of the public places.

Meantime Brutus and Cassius had gone into Asia and formed a strong army, intending, on the first favourable opportunity, to make war upon Octavius. Octavius and Antony passed into Greece on their way to meet the rival army, which was completely defeated at Philippi 42 B.C. Cassius and Brutus, seeing that all was lost, determined to die; Cassius compelled his freedman to kill him, and Brutus killed himself with his own sword. Octavius now settled down to the task of consolidating his power in Italy.

Antony and Cleopatra. Mark Antony remained in the East, and here met once again with Cleopatra, with whom he became completely enslaved. Antony and Cleopatra made war against Octavius, and the great sea-fight at Actium took place, in which Antony's fleet and men might have made a good fight but that Cleopatra had her galley withdrawn from the front, and Antony followed her in what seemed to be a flight. The Egyptian fleet was wholly defeated, and when his cause seemed lost, Antony committed suicide.

Cleopatra tried the effect of her charms on Octavius, but found him made of much less impressionable stuff than Antony; and, seeing no hope of gratifying her ambition, she put herself to death. Octavius was now, without any rivalry, the foremost man in Rome, Cleopatra being the last sovereign in succession of the great line of the Ptolemies. Octavius treated the remains both of Antony and of Cleopatra with all respect, and the pair were laid in earth side by side in the time-honoured burial-place of the Egyptian sovereigns. Octavius now had the government of Rome entirely in his hands. His wars had kept him out of Rome for some two years, but the affairs of the State had been well managed by his trusted representatives, and when he returned to Rome he found everything in good order, and prepared for the continuation and extension of his work of reconstruction. He found that he was entirely trusted by the people and in absolute command of the army.

He had now to decide whether he would accept the imperial power and proclaim himself the autocrat of Rome, or whether he would hold back from this extreme decision and keep up the appearance of being only the constitutional head of the administration, and the leading authority in the system of government. Octavius, with the prudence characteristic of him, declined to accept any imperial authority, and he still was in name the chief magistrate of a constitutional Republic. He saw what a hold the Republican form of rule had upon the Roman people in general, and how, despite increasing luxury and extravagance, men of the highest minds still strove to maintain the ideal Republican simplicity of life.

The Rule of Octavius. Octavius knew well also that if Rome could not emerge from her present state of chaos the imperial system would have to be tried, and he seems to have decided that it was his destined task to conduct a monarchy under all the external forms of a republic. It was the more easy for him because he had no taste for Imperial splendour or for prodigal display. He occupied only a modest and unpretentious dwelling, wasted neither the State's property nor his own in luxurious living, and conducted himself as any Republican householder might do. Even towards those orders and institutions which had been most unfriendly to him Octavius showed moderation and fair dealing in his endeavour to obtain a permanent settlement of public affairs. He reduced the numbers of the Senate, which had grown too large for efficient work, but did not diminish its authority in the sphere traditionally marked out for it, and his own name appeared like that of any other senator on the official list.

A New Order of Things. As soon as it became clear to Octavius that order had been restored, and that Rome had no longer any conspiracies threatening it, he resigned the exceptional powers which had been entrusted to him, and resumed the position of presiding magistrate over the State. The Senate decreed to him a new tenure of the dictatorship for ten years, with the understanding that the term of office should be renewed as often as might be deemed necessary in the interests of the country. Octavius accepted these conditions, and received from the Senate the title of Augustus. He was now Augustus Cæsar, and was to have precedence over all other men in official position. He was also proclaimed Commander-in-Chief of the army, and it was decreed that to him alone could belong the right of making treaties, of declaring war, and of offering or accepting terms of peace. He was Emperor in everything but the name, for it was certain that, so long as he lived and retained his popularity, there was no likelihood that an attempt would be made to put a limit to his time of office. Augustus did everything in his power to make the new order of things acceptable to the Senate. He announced to the senators that it was his intention to govern the State in co-operation with them and through the medium of their decrees, and not by sudden and Imperial pronouncements. A new and important chapter had opened in the history of Rome.

Continued

Group 2
ART
11
SCULPTURE

continued from page 1512

BRONZE CASTING

Colouring the Cast. Dividing the Mould. The "Cire Perdue" Process. Marble Cutting. Pointing and Finishing

By COURTENAY POLLOCK and P. G. KONODY

SHOULD it be desirable to give the plaster figure the colour and metallic appearance of bronze, the following method is perhaps the quickest of all, and the effect may be almost what you like, though it depends on the skill employed.

The plaster cast should in the first place be as dry as it will get if left in the studio for about 24 hours. The bulk of the moisture will evaporate, but the cast need not get perfectly dry. The following materials are required, in quantities varying according to the size of the cast to be coloured.

Of dry colours—royal blue, Vandyke brown, and lemon yellow or chrome; some shellac in flake, some very good bronze powder and some methylated spirit. Dissolve some of the shellac in spirit in the ratio of two good tablespoonfuls of shellac in half a pint of spirit.

The Colour. For a greenish bronze the first coat should be of a fairly bright green. Mix, as required, blue and chrome, and add a very little brown to quieten the tone. It should be borne in mind that more yellow is required than blue: a very little blue will go a long way. Mix it with the shellac, not thickly, and with a large hog-bristle brush cover the whole cast. It may be necessary to give two coats, but it is only required that the green shall not be so thin as to show the white plaster through it. Judgment must be exercised in using the shellac. If too much is taken the colour will shine, and spoil the desired effect. Each coat should dry so that only the very least shine is noticeable. Mix some bronze gold next. This should be very thick, almost stiff, but very little should be used on the brush. Just dab the end of the brush on the bronze and draw it lightly over the surface of the cast, avoiding the deeper hollows and allowing all the higher points to receive this colour. This, when toned down, will give the bright points of polish, similar to those on real bronze where slight rubbing has removed the colouring or oxidizing.

Bronzing the Prominent Parts. More of the gold bronze should be laid upon the most prominent parts, such as the bridge and tip of the nose, the highest parts of the hair, and the outer edges of the ear. Now mix some brown and add just a little of the green. Use it rather thin. Have a cloth in one hand to dab with, and do not use more colour than will just damp the brush. Go very lightly over the whole cast as quickly as possible, taking the colour a little more deeply into the hollows than you did with the bronze, but not touching the green in the deep places. Follow at the same time with the cloth in the other hand, dabbing lightly on the very highest points only to remove some of the brown colour. On the large flat portions, like the cheeks, neck, and on smooth hair, dab the cloth all over lightly. When this is quite dry, polish it over with a piece of velvet or very soft cloth.

Casting with Gelatine Mould. This method is employed when more than one cast of the same object is required, or when the detail of the modelling is too fine to admit of chipping off the plaster mould.

The modus operandi is as follows: Procure some of the best gelatine, not such as is used for cooking, but that sold for the purpose by Italian warehousemen or drysalters; the quantity varies according to the size of the model. Some French chalk, methylated spirit, and shellac in flake will be required. Place the gelatine in water until it is a little flexible, but do not soak it, as this would make it too thin to form a strong mould. Place it in a double saucepan, and, having filled the outer vessel with water, allow it to simmer over a fire until the gelatine is quite melted.

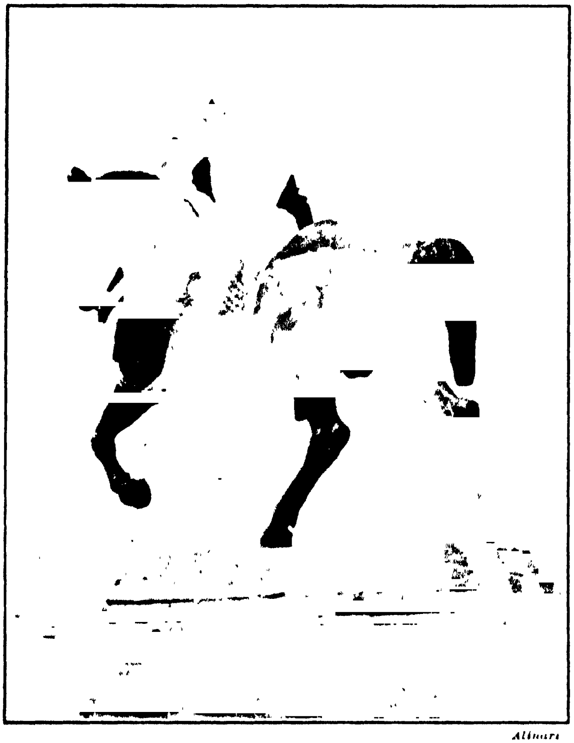
In making a mould upon a figure in the round it is necessary to make first an outer casing of plaster. The gelatine mould must be made in this as it does not stick on the clay like plaster. It takes some hours to set, and cannot therefore be thrown on to the clay. Allow the clay model to dry a little so that the surface is firm and not easily injured by pressure. Give it a thin coating of shellac all over, applied with a very soft brush.

Covering the Model. Roll out some clay 1 or 2 in. thick (for a small figure of 12 in., 1 in. will be sufficient). Cover the model with damp tissue paper, and lay the clay all over it, lightly filling the seams and smoothing over the whole surface. Oil the board round about the base and make the outer mould of plaster in two pieces, front and back, or as the shape of the model dictates; this is done by using the clay division, as in making a piece mould.

No coloured layer is required, as the case will not be chipped off, but removed in halves. Trim the casing round the base and mark its outline with pencil upon the board. Now remove it and the clay covering and the tissue paper. Having removed the clay from the plaster case, allow the latter to dry a little and then give it a good coating of shellac, after cutting a hole at the head through which to pour the gelatine. Smear the board round the base of the model well with shellac, and oil both that and the case. Now place the plaster case in position round the model, following the pencil outline on the wooden base. Bind the case tightly and fill the seam with clay, banking up round the base to prevent the liquid escaping.

Dividing the Mould. Pour in the gelatine at the top slowly, completely filling the case, and with a wooden mallet tap all over the outside, from the bottom upwards, to release any air bubbles that may have formed inside. Leave it for about six hours to set. If the inside of the plaster case has been properly covered with shellac, and well oiled, the halves will come away easily.

Cut through the gelatine mould with a fine, sharp knife, dividing it into halves. It is best to make this division at a point that does not correspond with the division of the plaster case.



Alinari

31. SCULPTURE OF THE OLD SCHOOL. THE COLLEONI STATUE. BY A. VERROCCHIO

Take off the gelatine mould and brush it quite clean, drying the inside with French chalk upon a very soft brush. Do not leave any powder in it, but blow into the hollows to remove it, then brush it over with olive oil or wax dissolved in paraffin. The mould is now ready to cast from.

Place the halves carefully together and put on the plaster case, binding it with cord. If the hole at the top is very large, it should be filled up with plaster. The opening at the base will be used for pouring in the mixture for the cast. When the mould is filled it should be well shaken about, as air bubbles are very common in using gelatine. The mould is removed in the same manner as before. Every successive casting is treated in the same way. If it is desired to keep the gelatine mould for a day or so, cover it with a waterproof sheet.

Bronze Casting. In casting in bronze the sculptor has nothing to do with the actual process beyond retouching the wax cast and finishing the bronze when necessary. The normal composition of bronze may be approximately fixed at nine portions of copper and one of tin; but the quantity of tin may vary from 8 to 10 per cent.

For the sake of lightness more than economy, works are not made solid, but are cast over a central and removable core. This is made first, and fashioned roughly into the general shape of, but smaller than, the model. It is made of a mixture containing modelling clay, pounded brick, and plaster-of-Paris. It is dried slowly, and the last particle of moisture removed by baking. Upon this the sculptor models his work in wax. This process, though very old, is being disused where the method which is about to be described can be employed.

The "Cire Perdue" Process. It is generally more convenient, and certainly quicker, to take one or more casts, as required, in foundry-wax, which is hard and firm. This should be made of about the same thickness as that necessary in the bronze cast. The sculptor retouches the wax, and the founder proceeds to make the bronze from it. The core is made by filling the wax model with the mixture of clay, pounded brick and plaster. The mould is then made by covering the whole with layers of composition of dried clay-brick or pounded crucibles and plaster, thoroughly ground, sifted and crushed, and rubbed into a soft, creamy substance. These layers are added as they dry, the sharpness and definition of the bronze cast depending upon the nature of the mixture. This is covered with a very thick mass of coarser material, and thoroughly dried. The wax is then melted out, and the mould heated. Ducts and vents are made in various places to permit the escape of air through the casing of the mould. This is done by attaching very small rods of wax to the extremities of the wax model before putting on the mould. When the whole is heated, these rods melt and run out from between the core and the mould, together with the wax shape of the model, leaving the ducts or air passages clear.

The bronze is run into the heated mould, and sets at once. Cooling takes some time. The mould is then carefully chipped away, and the core raked out. The bronze will have taken the exact shape of the wax, and, therefore, there will be rods of bronze in place of the wax rods projecting from the extremities. These are sawn off, and the roughness finished by the sculptor.

Colouring the Bronze. The bronze is coloured, according to the wishes of the modeller, by the use of chemicals, such as sal ammoniac, almond oil and flower of sulphur, or muriate of ammonia, one part, and subacetate of copper (verdigris), two parts, dissolved in vinegar by boiling, and brushed over the bronze. A very well-known method, and one which gives pleasing results, is to mix twelve parts of common salt with six of bi-tartrate of potash and two of sal ammoniac, dissolving in twenty-four parts of boiling water, and adding thereto from eight to ten parts of a strong solution of nitrate of copper. This mixture is washed over the surface, and the operation repeated as the coats dry. This gives the bronze a good antique colour, and may be polished with a fairly soft brush. But for the antique patina sal ammoniac is most valuable.

Use of Modelling Wax. Wax as a modelling medium is very useful in making sketches or memoranda of pose. It is also useful when very fine sharp detail is required, such as is necessary in silversmiths' work. The red wax sold by Messrs. Reeves is perhaps as good as any, as it is always fairly firm. There is also the "Italian Modelling Paste," which is more creamy, and of a brick-dust colour. It is useful for relief work, but is hardly firm enough for work in the round or where there is much projection

32. SCULPTURE OF THE MODERN SCHOOL
LA MAIN DE DIEU. BY AUGUSTIN RODIN

In using an armature for small wax figures it is best, if it is desired to keep the model, to use one stout piece of wire secured to the base and taken up the standing leg, and lighter wire for the rest of the form. Such an armature is easily bent about in finding a pose. Before putting on the wax the wire support should be dipped in melted resin or pitch, or it will become corroded by the wax. Copper wire is better than galvanised, on account of its softness. Keep the wax always covered when not in use; it is very difficult to clean

In designing a figure the lighter the armature the more easily it will be bent. It is well to remember this, as it will be found very convenient, when thinking out a pose, to twist or turn the sketch model into various positions.

Originality. Many students, having acquired sufficient technical knowledge to express themselves by the medium of sculpture, cast about for what is sometimes called a "style." If the student has learned his modelling from a good master, who has inspired him with confidence, he will probably absorb many of his master's ideas and adopt some of his methods. Failing this, he will perhaps "base" himself on a sculptor who has become well known on account of his originality. This is a very great mistake. It is but natural that the learner should, to a certain extent, follow the methods of his teacher, and in a measure fall into his manner of expression. But the desire to imitate the superficial characteristics of the work of others cannot be too severely condemned. To whatever extent he admires the work of a sculptor, be he bad or good, the student should resolutely resist the temptation to follow what may prove to be something he does not entirely understand. Originality is not a quality to be sought after. It is the *unconscious* outcome of conscientious and earnest study—study of books and examples of good sculpture [**31** and **32**], and, above all, the study of Nature. Originality is the outcome of imagination and knowledge.

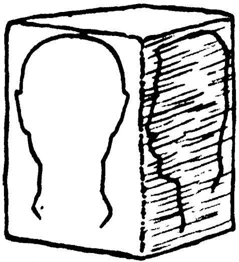
Marble Cutting. Comparatively few modellers nowadays can be said to be masters of marble carving or stone carving. This art is almost ignored in the British art schools. The student is given a training in modelling in clay, and is left to his own resources to acquire a knowledge in the use of the chisel. The consequence is that the majority of stone carvers are Italians, who are employed for want of English carvers. It is impossible to show without practical demonstration how to hold and strike a chisel, or how to point and finish the marble work; but a few hints will be sufficient to guide the student in learning these things by experience.

The marble is supplied in blocks and upon its surface the outline of the model is drawn thus:

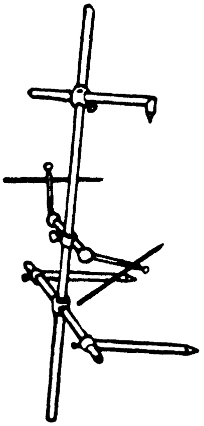
Roughing Out. Upon the front surface of the block the outline of the front view is drawn from the plaster model; upon the sides the side views are traced in the same way [**33**]. The outline is then cut on sides, front, and back, as shown in **34**. This is cut out to within about $\frac{1}{2}$ in. of the actual surface.

The "pointer" is then brought into use, to determine the exact projection of various points. It is too complicated to explain in detail, but the working principle may be described in this way.

The pointer has three arms, which are to rest on three chosen points upon the model, which cannot be fixed for general use, but must be selected as the design of the model demands. An example is shown in 36, one point being at the crown of the head, upon which the whole instrument depends, and two lower points rest upon the chest. The arms are now screwed up so that they are quite rigid. To this framework several flexible jointed pointers are attached. Before attaching the poin'er, three small lumps of plaster ½ in. thick should be fixed upon the model to receive the points of the instrument, and each lump should have a small piece of tin or copper sheet the size of a halfpennypiece, with a fine dent in the middle, such as may be made with the point of a wire nail. These will form secure and definite points upon which to rest the machine while taking measurements with the flexible pointers. [See 35.]



33. DRAWING ON THE STONE BLOCK

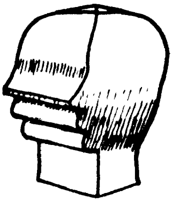


35. THE POINTER

Pointing. Corresponding points must be selected very carefully upon the marble, for when the measurements have been taken upon the model by bending the flexible arms till their points touch the projection required, the whole is lifted from the plaster model and placed upon the marble. The three projecting points of marble may be removed when the object is quite finished.

Pointing and rough carving preparatory to making a piece of sculpture are generally handed over to an ordinary carver, as it does not require very much skill, being purely mechanical, and demanding only accuracy. A machine has recently been invented which does this work with perfect precision, and in about a tenth part of the time necessary to do it by hand. It is consequently much cheaper and more reliable than handwork. In England the machine is used by the Sculpture and Carving Syndicate, at Southwark. It is a mistake to think that the use of such a machine is inartistic. It does only the mechanical work which would otherwise be performed by the sculptor's assistant. In chipping, the tools used vary in size and weight, according to the amount of marble to be removed. In finishing, a very much lighter mallet is necessary than the one required in roughing out.

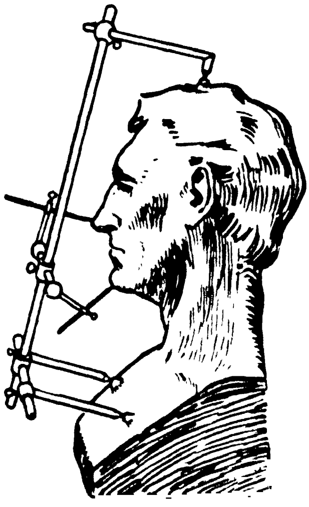
Finishing. It should be borne in mind when learning stone or marble carving that it is impossible to correct mistakes made by cutting too deeply. Where projections occur which are liable to be snapped by the weight of the mallet, such as the fingers or an arm, a supporting bridge of the material should be left, so as to strengthen the part by attaching it to a heavier mass. The hand or arm may thus be attached to the figure at the tips of the fingers or at the wrist and elbow. These attachments should be removed with great care when the parts are quite finished, and only light tools should be employed for the purpose—small, light chisels, riffles, and, if a high finish is required, sandpaper, emery paper and polishing brushes.



34. STONE BLOCK ROUGHED OUT

In finishing a model it should be placed in a half light, so that it is illuminated from one side only. The plaster model should be placed in the same light. By this means irregularities of contour are discovered. Keeping both plaster and marble in the same light, they should be turned round a little at a time, so that the outline may be seen from as many points as possible.

Reducing and enlarging from a model is also done by pointing machines. Exactly the same process should be followed, with the exception that the reducing or enlarging machine has a pointer to trace over the model, and a drill to rough out the reduction or enlargement in the marble.



36. THE POINTER APPLIED

Sculpture concluded

POSTS IN THE EDUCATIONAL ARMY

The Educational Acts. The Controlling Authorities. Teaching Staffs in London and Elsewhere. Salaries and Promotion. Technical Colleges

continued from page 1498

By ERNEST A. CARR

EVERY person of alert intelligence recognises to-day the intimate relation existing between efficiency and training, whether viewed from the personal or the national standpoint. It is unnecessary, therefore, to insist at length on the vast importance of popular education, and the responsibilities of those into whose hands such a vital trust is committed. In England and Wales recent legislation has confided most of this power to the greater municipal authorities, and there is perhaps no single department of local government work which can compare with it in essential value.

Education and Popular Control. Without seeking to trace even in outline the history of the education of the people since the great basal statute of 1870, we must consider briefly the position existing prior to the operation of the Education Acts of 1902 and 1903. Of the two great classes of State-aided elementary schools, the voluntary, or denominational section, accommodating more than half the total number of scholars, was mainly dependent for its support upon revenues derived from private sources. The Board schools, on the other hand, were controlled by local school boards, and maintained chiefly from the rates. With a few exceptions, municipal authorities had no part in the direction of elementary schools of either class. Secondary training was (as now) partly controlled by county councils; but between these two detached systems of primary and more advanced education the uniformity and cohesion were lacking which might fashion them into a single effective instrument of national education.

The Education Acts of 1902 and 1903. The state of things thus sketched has been radically changed by these much-debated measures, the first of which affected all England and Wales, save London only, and the latter the capital itself. It is even yet too early to determine exactly the extent of the changes they have introduced; but, apart from certain controversial features with which we are not now concerned, the two statutes certainly tend to unify the educational system of the country, and to place it on a wider basis than before. And the aim of the new method is popular control through the municipal representatives of the people.

Effects of Legislation. The most striking changes effected by these acts are the abolition of the school boards, the transference of their buildings (now known as "provided" schools) to municipal bodies, and the control by these latter authorities, so far as secular education is concerned, of the voluntary, or "non-provided" schools. These and other changes are thus admirably summarised by an educational expert: "By the passing of the Education (London) Act of 1903, the complement of the Education Act of the previous year, the finishing touch was given to an administrative upheaval, the like of which has not been witnessed since the Local Government Act of 1888 became law. The Acts produce not so much a change as a revolution in our system of national education. At one stroke the elaborate machinery of school boards elected to deal with elementary education is wiped out of existence, educational interests of all kinds—elementary, secondary, and higher—are coordinated, and the power given to municipal authorities throughout the country. A notable result of the change made is that for the first time the voluntary, or, as they are termed in the Acts, 'the non-provided' schools, are brought under a certain measure of popular control, and are supported out of the rates, except with regard to the maintenance of the school fabric in a condition of repair—an obligation which still has to be discharged by the trustees of the school."

A Colossal Task. Some idea of the magnitude of the labours thus devolving on municipal bodies who are made education authorities by these Acts may be gathered from the latest educational returns. These show the number of elementary schools under inspection in England and Wales to be 20,285, with accommodation for nearly 7,000,000 scholars, a total of 6,795,484 children on the books, and an actual attendance of 6,024,543. The task of educating this mighty army of scholars is entrusted to 160,736 teachers, and costs the country considerably more than thirteen millions sterling every year. These figures, it should be noted, relate to primary education alone. To the duties they denote must be added "the general co-ordination of all forms of education"—involving the maintenance and management of municipal secondary schools and technical colleges, the training of teachers, and the creation of an adequate "ladder of learning" by means of council scholarships to higher grade schools and the universities. As an instance of the liberal way in which this last obligation has been interpreted by the authorities concerned, it may be mentioned that in London alone over 5,000 scholarships are now offered each year.

The Education Authorities. The statute of 1902 created provincial education authorities of three grades, under the general control of the Board of Education. County councils and county borough councils have full powers for the purposes of the Act; while boroughs numbering over 10,000 inhabitants, and urban districts of above 20,000, have charge of elementary instruction only. The education authorities thus formed are as follows:

62	counties
71	county boroughs
144	larger boroughs
58	larger urban districts
335	

The Act of 1903 added but one new member to this list—the London County Council, which is the sole educational authority within its area. There are also a number of "minor local authorities," comprising 110 boroughs and 748 urban districts, with powers restricted to the levying of a rate for the purposes of higher education.

Each authority acts through an education committee, appointed mainly by itself from its own ranks. In London no fewer than 38 members in a committee of 43 are County Councillors. These delegate bodies are invested with wide executive and advisory powers; but the local authority may disregard the advice of its committee, and remains subject in supreme control only to the mandates of the Education Board.

The Teaching Staff. The position of municipalities as education authorities being thus indicated, we may turn to consider the nature of the employment they offer in this capacity. It is noteworthy, by the way, that the local council appoints the staff of its provided schools, and that its consent is required to the appointments made by the managers in non-provided schools.

A recent report of the Board of Education affords some interesting information as to the numbers and pay of the teachers in municipal schools in this country. Apart from 2,172 probationers of both sexes, the teaching staff is constituted as follows:

	Male.	Female.
Certificated teachers	27,260	47,460
Uncertificated	5,605	35,110
Supplementary and provisional assistants	55	18,241
Pupil teachers	4,151	20,682
	37,071	121,493

The salaries of the *certificated* teachers in English and Welsh public elementary schools, some of whom occupy a house free of charge, are classified thus:

Annual Salary.	Masters.		Mistresses.	
	Principal.	Assistant.	Principal.	Assistant.
Under £50 ..	2	2	59	670
£50 to £100..	1,787	5,157	9,681	22,393
£100 to £150.	5,384	6,068	5,421	5,452
£150 to £200..	3,145	1,848	1,392	45
£200 to £250..	1,685	10	625	—
£250 to £300..	744	1	143	—
£300 to £400..	466	—	13	—
£400 and over	38	1	—	—
Total ..	13,251	13,087	17,384	28,560
Average Salary	£156 11 6	£112 4 4	£104 0 1	£80 15 4

The upward trend of salaries in the educational service generally may be seen by comparing the figures last quoted with those of two years earlier. In the same four classes the average salaries were then: £148 17s. 0d., £108 11s. 5d., £98 7s. 10d., and £78 13s. 7d.

A detailed account of the conditions of service under each of the 335 educational authorities—the salaries they pay and the qualifications they demand of teachers of every grade—would fill a bulky volume. These particulars can generally be obtained in respect of any single area from the secretary to the education committee of the local council concerned. Our purpose in the present course will be served best by reviewing at some length the methods of a typical council, and adding whatever comments are requisite as to the educational service generally.

The London County Council. The choice of an authority need not detain us for a moment, for London possesses in its County Council by far the greatest and most influential of them all. The explanation is that the sway of other county councils is broken by the occurrence of county boroughs and less important education authorities within their area. The London Council, however, under the terms of its own special Education Act (that of 1903), is supreme throughout the length and breadth of its district. As Pope said of Addison, it "bears, like the Turk, no rival near the throne."

London's Educational Army. The Council's Education Committee, according to the last available returns, had charge of 527 provided and 437 non-provided primary schools, with a total average attendance of 666,714 children, and a teaching staff that numbers 14,835. It also controls the most efficient set of special schools in the kingdom, comprising centres for manual training, wood and metal work and household duties, institutions for mentally and physically defective scholars, industrial and truant schools, technical institutes, and twelve training colleges. All these furnish occupation for 6,824 other instructors, making a total teaching staff of 21,659—a number which will be considerably augmented in the next statistics. The committee is also giving effect, at an annual cost of £174,500, to the elaborate system of scholarships already mentioned, which is designed to afford every capable child in London an opportunity of securing a thorough education free of charge.

Salaries of Teachers. The advantages of the London service as a career are well illustrated by comparing its average salaries with those given in the previous table. In London the average salary for head masters is £289 6s. 5d., and for their assistants £144 0s. 1d.; while among women the corresponding figures are £206 6s. 9d. and £108 16s. 10d.

Candidates for pupil-teacherships under the London County Council must be 16 years old, and must pass an educational examination. They are then attached to a centre for two years, receiving instruction for half their time and teaching in day-schools for the remainder. Boys are paid in their first year, £32 10s. 0d.; and in the next, £39; the amounts for girls being £20 16s. and £26. The pupil-teachers then enter a training college for either a year or two years, boys receiving meantime an allowance of £18, and girls £15. Candidates are also admitted direct to the training colleges at the age of 18 or 19, men receiving under these conditions a Government grant of £25 a year, and women £20, during their course. On completion of their training they pass the "certificate examination," and are appointed as assistants.

Salaries of Certified Teachers. The salaries at which certificated teachers begin are determined by their training and ability. Men who, after two years' training, pass in the first or second division, receive £95 a year. The lowest figure, £75, is reserved for third division men of not more than a year's training. In similar fashion the initial rates for women vary between £84 and £70. These figures will eventually be increased to a salary beginning at £100 for men and £90 for women. Certificated teachers holding a degree, or training for three years, receive an additional £10 yearly; and the same allowance is made to untrained graduates and to Associates of the Royal College of Science or the City and Guilds of London Institute, provided they possess certain qualifications in the theory and practice of teaching.

Men and women who have not passed the Council's certificate examination, but hold some recognised educational diploma, are accepted as uncertificated teachers at fixed salaries, on condition that they become certificated within five years.

With these exceptions, the annual increments are, in the case of men, £5 for the first two years, and £7 10s. thereafter, to a maximum of £200, subject to a special report on reaching £150; and, in the case of women, £4 to a maximum of £150, subject to a special report on reaching £130.

Regulations for Promotion. To regulate the promotion of assistants to principal rank, the Council's Education Committee has adopted the system of framing an Annual Promotion Register, limited to 225 selected names. When a head teacher's post becomes vacant, no application from an assistant is entertained unless his name is on the register. In this way the number of candidates for such positions is kept within practicable limits.

Head Teachers. The salaries of head teachers in the London service are as follow:

Elementary Schools: Grade.	Accommodation	Men.	Women.
		Salary and increments.	Salary and increments.
I.	1—200	£10 more than salary under scale for assistants	£10 more than salary under scale for assistants
II.	201—400	£200—£300 by £10 annually	£160—£225 by £8 annually
III.	401 and upwards	£300—£400 by £10	£225—£300 by £8

The principals of pupil-teachers' centres, secondary schools and technical colleges, are more liberally remunerated, the average rates in London ranging from £500 to £750 a year. Such posts are frequently advertised, and attract candidates of considerable scholastic attainments and wide experience.

Instructors in Special Subjects. Teachers of cookery, laundry work, and housewifery must hold either first-class teaching diplomas in these subjects, from a recognised training school, or some higher qualification. They are paid £80 a year, rising by £5 yearly to £120. Drawing teachers of permanent rank are required, as a rule, to possess the art-master's certificate, to be capable of teaching clay modelling and elementary design, and to have had experience in teaching. The scale of salary for men is £175, advancing to £200, and for women a minimum of £125, and a maximum of £150. The hours of duty are 27½ weekly. Instructors in metal work and wood work at day-schools are, in some instances, trained at the Council's technical schools, entering as lads at 5s. a week, and advancing through assistant grades to the rank of instructor, with an initial salary of £100, and a maximum of £155 a year. These posts are sometimes offered to outside applicants at the above salary. In technical centres the remuneration is by fee of 15s. per half-day of actual duty, five such periods constituting an average week. For the teaching of modern languages to day scholars a staff of visiting instructors is engaged. They must furnish proofs of their proficiency as teachers, and are paid 4s. for the first hour and 2s. for each consecutive hour at the same school.

In centres for mentally and physically defective children, all certificated assistants receive £10 more than in ordinary schools, but are restricted to the same maximum. Male teachers of the blind, if uncertificated, begin at £90, and rise to £140 a year; for women the limits are £70 and £115. The instruction of deaf children is remunerated at slightly higher rates.

Evening Schools. Most of the teaching posts in the Council's evening schools are held by members of the day staff, who receive extra pay, varying from 4s. an evening up to £125 a year. A number of these posts, however, are open to other than officials, and are advertised in the daily Press. In art, science, and advanced commercial subjects the usual rate of pay for an evening of three hours is 10s. 6d. to instructors, and 7s. 6d. to their assistants.

The conditions of employment for all special teachers can be obtained on application to the Executive Officer, L.C.C. Education Offices, Victoria Embankment, W.C. Information concerning them is also given from time to time in the official journal of the Council, "The London County Council Gazette," published weekly at 4, Great Smith Street, Westminster, S.W. To complete our survey of the Council's educational staff, two further classes of appointments should be noticed, whose duties are administrative and executive rather than directly concerned with teaching.

Chief Inspector's Branch. Vacancies in this branch are advertised as they occur. The salaries are as follows: Assistant inspectors, £250, rising by annual increments of £15 to £400 a year; district inspectors, £400, rising by £25 to £600 a year; divisional inspectors, £600, by £25 to £800 a year. There are also inspectorships of special subjects—*viz.*, art, wood and metal work, domestic subjects, needlework, etc.—at salaries varying from £120 to £500 a year. Candidates for these appointments have to be specially qualified in the subject in which they are required to inspect.

There are no restrictions as to age or sex of candidates for any of these appointments; but as the officers appointed are required to assist the Council's district inspectors of day, evening and technical schools, it need hardly be said that candidates should have some special qualifications for these duties.

The Visiting Staff. Some 400 visitors or attendance officers are employed in investigating cases of absence from school, interviewing parents, and otherwise checking truancy. Vacancies in the "unattached" section of this staff are usually advertised in the public Press or in the Council's own organ, above-mentioned. Unattached visitors receive £80 a year. Applicants must be between the ages of 25 and 35 (40 in the case of non-commissioned officers in the Army and Navy, or members of the Police Force of not less rank than sergeant). From the applicants a number are chosen to submit to an elementary educational test, and from those who are successful in this the candidates for the appointments are selected. Successful candidates must produce proof of age, and submit to a medical examination. Vacancies in the divisional staff of visitors (£80 a year, rising to £130) are filled by promotions from the unattached staff.

Notes on Provincial Authorities. As already indicated, London stands alone in the extent of its educational problem, and few other principalities have framed a scheme of instruction which approaches that of the capital in completeness. Most of the leading authorities, however, are giving due effect to the provisions of the Education Act of 1902 respecting the training of teachers and the co-ordination of all grades of instruction. The number of teachers furnished by the older *régime* having proved generally insufficient under the new system, it has been necessary in many areas to establish other training colleges for pupil-teachers, and to promote an adequate supply of candidates by means of exhibitions, bursaries, and scholarships. When this want has been met, the partial withdrawal of such inducements may reasonably be expected. The present is therefore a peculiarly favourable time for boys and girls to enter the calling of elementary school teachers.

Local conditions in different parts of the country are responsible for many variations from the educational type displayed by the London scheme. In the agricultural districts, for instance, greater prominence is naturally given to such training as shall fit the senior scholars for successful cultivation of the land. Hence, the Councils of Lancashire, Hampshire, and other counties have established farm schools, in which pupils receive instruction in dairy farming and poultry rearing on a basis at once scientific and practical. In some instances the consent of the Board of Education has been obtained to the introduction of these subjects into elementary day-schools, children of 12 and upwards learning farm and garden work for two or three afternoons each week.

Technical Colleges. In the great manufacturing and industrial centres, on the other hand, where workshops and factories absorb a large proportion of the pupils leaving school, technical training is correspondingly developed.

Evening classes and polytechnics afford instruction not only in applied science but also in industrial subjects—dyeing and bleaching, bookbinding, weaving, and similar work. The experts who teach these studies are generally well paid. The educational staff of the famous Municipal School of Technology at Manchester, for example, includes a director of paper-making and bleaching at £500 a year, and professorships in photography, tinctorial chemistry and textile fabrics, at salaries of £400 a year each. More strictly scientific posts on the same staff are remunerated with stipends ranging as high as £700, and the principal of the school receives £1,000 a year. Indeed, with the exception of a few administrative heads, the best-paid officers in the educational service are usually to be found among the professors of the technical colleges.

A Last Word on the Service. Comparisons show that the Educational Committee for the capital is distinctly more stringent as to the qualifications of teachers than the majority of education authorities elsewhere. This is amply compensated, however, by its more liberal rates of pay, in which respect it is rivalled only by a few of the leading corporations.

With regard to the education service generally we may close as we began, reminding ourselves that to have a part in the training of the coming race of citizens is to share in a great and honourable national duty.

Continued

Continued from page 1662

FRANCE

Position, Climate, and Products. Mountain and River Systems. The Rhone, Saône, Seine, Loire, and Garonne. The Landes and Corsica

By Dr. A. J. HERBERTSON, M.A. and F. D. HERBERTSON, B.A.

Advantageous Position. France (204,000 square miles) fronts three seas—(1) the English Channel on the north, (2) the Atlantic on the west, (3) the Mediterranean on the south. On all shores it has excellent harbours and busy ports, with easy access to all parts of the world. Its lowlands are broad and compact, forming a great semicircle around the Atlantic and the Channel. On the Mediterranean coast the highlands approach nearer to the sea, but, except in the extreme east, there is a coastal plain of no great breadth, widening in the centre to the plain of Languedoc. Every part of the most populous district, therefore, has easy access to the sea, and, as the canal system of France is excellent, merchandise can be easily and cheaply transported to all parts of the country [**81**].

Climate and Products. France is as favoured in climate as in situation. The surrounding seas make the winters mild and the summers cool, though in the south the latter are hotter than an Englishman finds pleasant. The Atlantic winds bring rain, and as the coast is low the rainfall is more uniformly distributed than in Britain, where the mountainous west is too wet. Except in the highlands, the soil is generally fertile, and admirably cultivated, for France is, in the main, an agricultural country.

Normandy, opposite the Isle of Wight, is a chalk region like Southern England, which it resembles in climate and products. Its apple orchards and cider are famous. Farther east much sugar beet is grown. Brittany, opposite Cornwall and Devon, resembles them in scenery, climate, and products. The centre, with its warm, sunny summers, ripens magnificent harvests of wheat, and brings the vine to perfection. In the south, in addition to the vine, the olive is grown for oil, and the mulberry to feed silkworms. Along the Mediterranean oranges and lemons ripen in the open air.

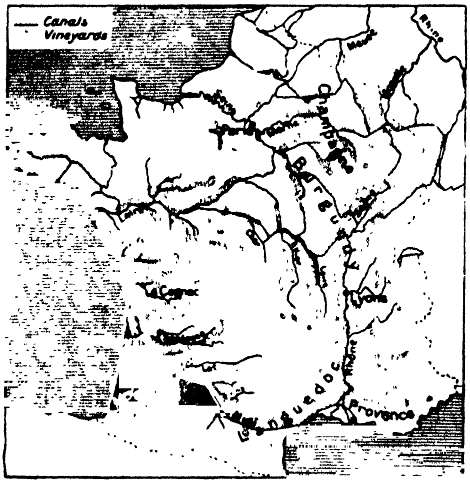
The Peasant and the Land. The French peasant commonly owns the land he works, and he gets a good living from it. Economy of soil is his watchword. The hillsides are terraced, especially in the vine districts [**81**], and not an inch of soil is wasted between the rows of vines. A fruit-tree is put in if there is room, and, if not, a fruit-bush. If that is too large, the peasant makes room for a clump of potatoes, asparagus, or artichokes, or at least for a patch of salad. In the plain the farms make a dazzling show from April to November, with "sky-blue flax, dark green hemp, crimson clover, bright yellow colza, golden wheat, stately Indian corn, and creamy buckwheat"—all, perhaps, on a farm of two or three acres. Fruit-trees cover the houses, line the roads, and form the hedges. Add to these poultry, and it is not wonderful that the French peasant saves money, for he has much to sell and little to buy.

What France Lacks. France would have been a different and, perhaps, a less generally prosperous country, had coal been abundant instead of scarce. The largest coalfield is in the north-east, on the Belgian frontier, where numerous towns manufacture textiles, of which Lille and Roubaix are the chief, obtaining cotton and wool through Dunkirk and the Channel ports. A number of smaller coalfields are found round the Central Plateau, and support iron and textile industries. The most important is that of St. Etienne, which manufactures iron and steel, and sends coal to the silk factories of Lyons. These are not the only manufacturing centres, but in the others coal has to be brought from a distance. French manufactures, therefore, are mainly those in which a high degree of skill or taste compensates for greater cost of production, and they cannot compete in cheap, common articles. Unemployment, therefore, does not become so acute as with us, nor is there the same rush from the country to the towns.

The Highlands of France. The highlands are in the east and centre. In the north-east, partly in Belgium and Germany, are the Ardennes, with the Meuse flowing through their western part, with the Moselle flowing round the south-eastern base to the Rhine, and farther south the Vosges—both forested. Round the former, near the northern coalfield, are Valenciennes, Cambray, and other towns, manufacturing cotton and wool, the latter produced in part on the hill pastures of the region. To the Vosges, where cotton is also manufactured, the raw materials are brought by the Seine and the canals connected with it, and coal from the coalfields of Lorraine. Water-power is also used more and more after being transformed into electricity. These northern highlands are connected westwards with the Plateau of Langres, the lower slopes of which produce the famous wines of Burgundy. The Seine basin to the north is a series of clay plains and limestone and chalk heights, on the slopes of which grow the grapes from which champagne is made. To the south rises the Central Plateau, with bare tablelands of granite, where cattle are reared, and of limestone with sheep farms; here are also volcanic mountains, the soil from which, when carried to the Loire and Allier plains which intersect the plateau, makes them very fertile. The south-eastern rim of the plateau, known as the Cevennes, forms the western wall of the Rhone valley, east of which, cut by the valleys of rivers descending to the Rhone, rise the Jura and French Alps, the latter with forests and pastures below and snow peaks above. In the small Jura towns such industries as clockmaking are carried on, often by water-power.

The Rhone-Saône Valley and the Riviera. This valley separates the Central Plateau of France from the Alps, and opens a route from the north to the Mediterranean. Had it not existed, France would have been, in no real sense, a Mediterranean power.

The Saône rises in the Plateau of Langres, and flows south-west and south through the wine districts round Dijon, receiving tributaries from the Jura on the left bank. It joins the Swiss Rhone, from the Swiss Alps, at Lyons—a great industrial town, manufacturing local and imported silk with St. Etienne coal. The united river flows south in a valley which widens as the mountains on either side recede, through a land of olive, wine, and silk, to the plain of Languedoc, where it forms a great delta with marshes and lagoons. Marseilles, the chief port of the Mediterranean, is some distance east of the delta, and beyond is Toulon, the French naval station. Here begins the picturesque coast of the Riviera, with white towns—Hyères, Cannes, Nice, and many others—half hidden in palms and orange groves, while behind rise the snowy summits of the Alps.



81. THE CANALS AND VINEYARDS OF FRANCE

West of the Rhone delta is Nîmes, with a large Roman amphitheatre, the old university town of Montpellier, and the wine port of Cette. Other southern towns are Narbonne, commanding an important route to the west by Toulouse between the Central Plateau and the Pyrenees, and Perpignan.

The Pyrenees. The Pyrenees rise like a wall between the Mediterranean and the Bay of Biscay, forming the frontier between France and Spain. The highest peaks are about 11,000 ft. high, and there are few easy passes. The lower slopes are forested with oak and beech, the higher summits rocky or snow-clad. Of many health resorts, Pau and Biarritz may be mentioned.

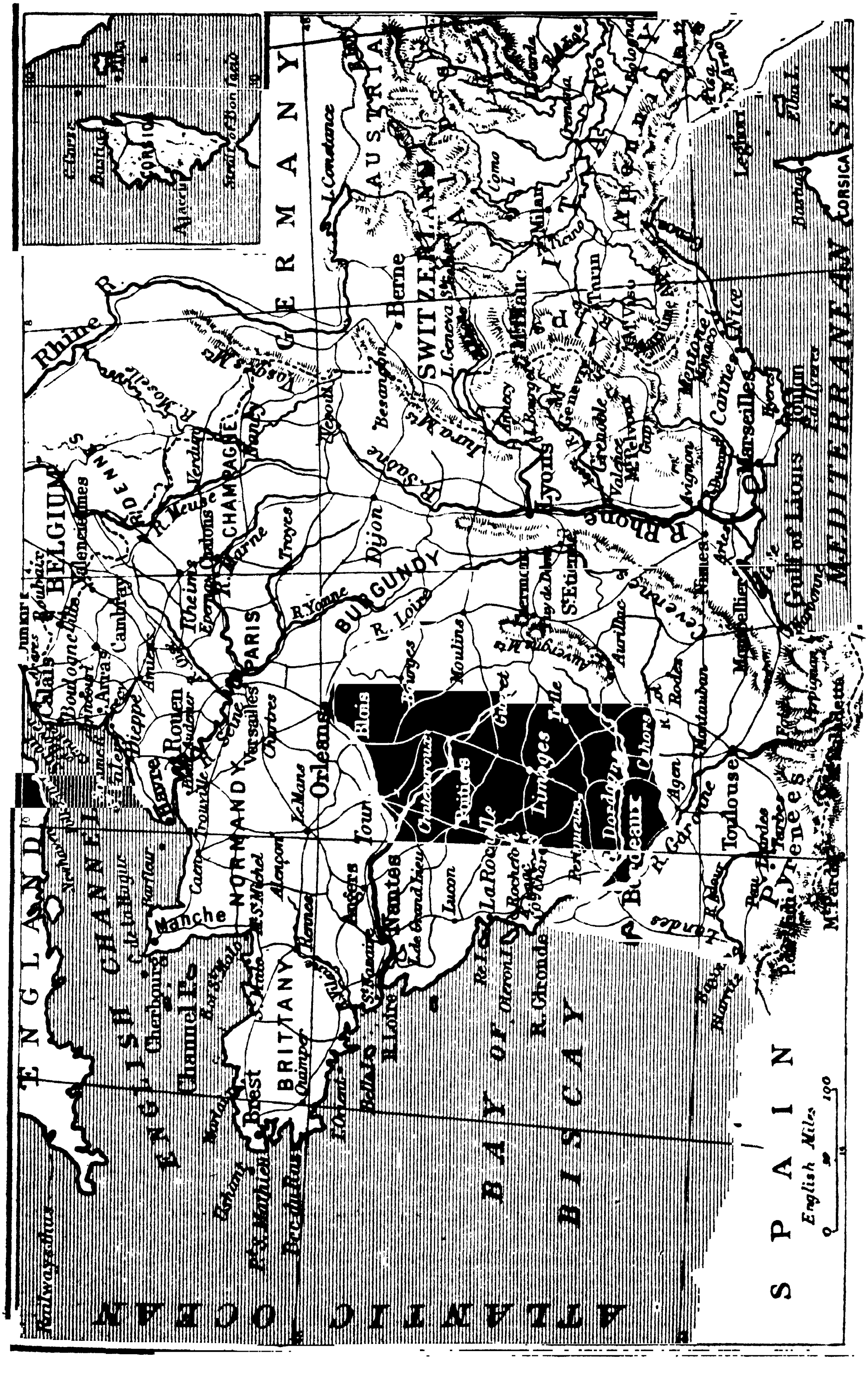
The Atlantic Lowland. From the base of the Pyrenees, the Central Plateau, the Vosges, and the Ardennes, stretches a great semicircular lowland, extending to the western and northern seas, and broken by heights along the English Channel. It is continued east beyond the French frontier by the lowlands of Holland, Belgium, and Germany. This is a fertile agricultural region, with many prosperous towns, often with fine cathedrals and public buildings, showing that the region has long been peaceful and prosperous.

From the highlands, three great rivers, the Seine, the Loire, and the Garonne-Dordogne, flow north or west, each with a special character of its own.

The Seine Basin—a Familiar Landscape. Northern France, with its orchards and wheat fields, reminds an Englishman of his own country, for the rolling chalk landscape of Southern England is also found on the French side of the narrow Channel. His eye misses the hedgerows between field and field, and notes that the poplar gradually replaces the elm. Unfamiliar touches are the blue blouses of the peasants, and women doing hard field work instead of men.

If the Englishman sails from Dover he lands at Calais, on the margin of the industrial district round Lille and Roubaix, both woollen towns. From Folkestone he arrives at Boulogne, a busy port, and makes his way, near the battlefields of Creçy and Agincourt, to the Somme, on which is Amiens, with a magnificent cathedral. From Southampton he reaches Havre, exactly opposite, at the mouth of the Seine, and, if he will, may sail up that river to Paris, the capital of France. The first great town he reaches, with its iron cathedral spire, many churches, and forest of factory chimneys, is Rouen, the Manchester of France, whose docks admit ocean-going steamers, laden chiefly with cotton. Elbœuf, not far off, manufactures woollens. Paris, 70 miles direct from Rouen, but much farther by water, is one of the gayest, brightest cities in Europe. It is built on islands in the Seine, and on both banks. The finest of its ancient buildings is the cathedral of Notre Dame. Its modern quarters have broad streets with avenues of trees, great squares with fountains and triumphal arches and columns, dazzling shops, and parks great and small. Many industries are carried on, and the city is the great place of exchange, both for merchandise and ideas. Not far below Paris the Seine receives the Oise, from the Ardennes, and above it its tributaries spread out like a fan, offering a choice of routes into the heart of the country.

Tributaries of the Seine. The Marne, entering the Seine just above Paris, has flowed down from the Plateau of Langres,


ENGLAND
ENGLISH CHANNEL
ATLANTIC OCEAN
BAY OF BISCAY
SPAIN
English Miles
0
100
BELGIUM
GERMANY
SWITZERLAND
AUSTRIA
ITALY
MEDITERRANEAN SEA
Gulf of Lions
CORSICA
Rhine
R. Moselle
Vosges Ms
Jura Ms
Pyrenees
BRITTANY
NORMANDY
CHAMPAGNE
BURGUNDY
ARDENNES
PARIS
Versailles
Chartres
Orleans
Blois
Tours
Le Mans
Alençon
Rennes
Brest
Quimper
L'Orient
St. Malo
Cherbourg
Caen
Trouville
Havre
Rouen
Dieppe
Amiens
Arras
Cambray
Boulogne
Calais
Dunkirk
Roubaix
Valenciennes
Rheims
Epernay
Chalons
R. Marne
Troyes
Verdun
R. Meuse
Nancy
Vesoul
Besançon
Dijon
R. Saône
R. Yonne
R. Loire
Bourges
Moulins
Nevers
Nantes
Angers
La Rochelle
Rochefort
Luçon
Poitiers
Châteauroux
Guéret
Limoges
Tulle
Périgueux
Dordogne
Bordeaux
R. Gironde
Landes
R. Garonne
Agen
Cahors
Montauban
Toulouse
Pau
Tarbes
Bayonne
Biarritz
Perpignan
Carcassonne
Narbonne
Montpellier
Nîmes
Arles
Avignon
Marseilles
Toulon
Cannes
Nice
Monaco
Mentone
R. Rhône
Lyons
St. Étienne
Clermont
Puy de Dôme
Aurillac
Rodez
Cévennes
Auvergne Ms
Grenoble
Valence
Gap
Annecy
Chambéry
L. Geneva
Geneva
Mt. Blanc
Berne
L. Constance
Como L.
Milan
Turin
Genoa
Leghorn
Pisa
Bastia
Ajaccio
Strait of Bonifacio
Railways

82. FRANCE.

through a wine country, a few miles south of Rheims, in whose ancient cathedral French kings were formerly crowned. Rheims has now important woollen manufactures. A splendidly engineered canal, nearly 200 miles long, goes by Bar-le-Duc, and near the university town of Nancy, to the Meuse and Moselle, and thence across a depression in the Vosges to the Rhine near Strassburg. Or we may follow the Seine through the forest of Fontainebleau, and past Troyes, to its source in the Plateau of Langres. Finally, the Yonne takes us towards the Loire, which is separated from it by broken heights. The Burgundy Canal, 1,200 feet above the sea at its highest point, goes from the Yonne by Dijon to the Saône, thus connecting the English Channel with the Mediterranean.

Normandy and Brittany. East and west of the lower Seine is Normandy, its swelling hills covered with cornfields, and its valleys rich with orchards and meadows. Innumerable herds of cattle supply milk for the famous Normandy cheeses. Many towns, cathedrals and abbeys tell a tale of long prosperity. Cherbourg, opposite the Isle of Wight, on the Cotentin peninsula, is a naval station. Dieppe, east, and St. Malo, west of the Seine, are important packet and fishing ports. A few miles north of the latter are the Channel Islands. Brittany, opposite Cornwall and Devon, is a highland region, growing early vegetables in the north. Fishing is important all along the Channel coast, and both Normans and Bretons are born sailors. On the Atlantic coast are the naval ports of Brest and Lorient.

The Loire Basin—a Garden Land. The Loire, 550 miles long, the longest river in France, rises 4,500 feet above the sea, in the heart of the Cevennes. It is a rapid river, liable to destructive floods in its lower course, where its banks have to be protected by dykes and embankments. The main stream flows generally north as far as Orléans. On a tributary in its upper course is St. Etienne, with collieries, ironworks of all descriptions, and ribbon and other manufactures. Below Nevers it unites with the Allier, greater than itself in volume, which flows from the volcanic district of Auvergne, not far from Clermont, the largest town of the Central Plateau, in a fertile wheat and vine growing vale with a rich volcanic soil. All round this volcanic region, whose scores of extinct craters, seen from the summit of the Puy de Dôme, produce an indescribable impression on the mind, are mineral springs of high repute, as at Vichy, on the Allier. At Orléans, the centre of one of the most fertile districts of Europe, the Loire turns west, to flow by Blois, Tours, Angers, and many a famous château, through the rich districts of Berri, Touraine and Anjou, which form the garden of France. On the left bank it receives tributaries from the Central Plateau and on the right bank tributaries from the Norman heights. Nantes, at the head of the estuary, is the Liverpool of Western France, and the rival of St. Nazaire at its mouth.

The Garonne - Dordogne Basin. The Garonne is formed by the union of streams from the Pyrenees, which unite above Toulouse, a town important from Roman times because it commands the route to the Mediterranean between the Cevennes and Pyrenees. This depression is followed by the Canal du Midi, from Toulouse to Cette, uniting the Garonne with the Mediterranean. On the right bank the Garonne receives many tributaries from the Central Plateau, and these flow through some of the strangest scenery in Europe.

A Strange Country. The surface of the limestone Causses, as these districts are called, is a bleak, barren stone plateau, burnt up in summer, and buried in snow in winter. The only sign of life is an occasional shepherd with his flock. The rivers cut deep narrow gorges many hundreds of feet below the surface, enclosed between rock walls carved into strange shapes by wind and weather, and flaming with all the colours of sunset. Precipitous paths lead down to the bottom of the gorges, which are often inaccessible except by boat, but in places widen out sufficiently to hold many a village, with orchards and gardens, hidden, as it were, in the bowels of the earth. The few towns are often finely situated on precipitous ridges.

The Dordogne. The largest tributary of the Garonne is the Dordogne, which rises in the old volcano of Mont Dore, in Auvergne. It enters the Gironde estuary a few miles below Bordeaux, the chief port of south-west France and the outlet for the clarets of the surrounding wine districts. Pauillac, at the mouth, is the outport of Bordeaux.

A Reclaimed Desert. The Landes. Immediately south of the Gironde is the wine district of Medoc, and beyond are the desolate Landes, a region of sand dunes, in places 250 feet high, and extending inland for 120 miles. Their advance eastwards has been checked during the last century by planting millions of pines, which yield valuable turpentine. The vine has also been successfully introduced. The inhabitants live in small scattered villages and cross the dunes on tall stilts.

Corsica. The mountainous island of Corsica (3,400 square miles), in the Mediterranean, is over 100 miles from France, of which it forms a department. Its mountains rise to nearly 9,000 feet. The lower hill slopes facing the sea are planted with olives, vines, oranges and lemons. Above there are dense forests of evergreen trees peculiar to the Mediterranean. Minerals are abundant, but little worked. The capital is Ajaccio.

Continued

WATER POWER APPLIANCES

Hydraulic Rams and Syphons. Types of Water Wheels. Pelton Wheels. Varieties of Turbines. The Horse-Power of Water

APPLIED MECHANICS
continued from page 1577

By JOSEPH G. HORNER

THIS article deals with the applications of hydraulics, the leading principles of which have been already stated. The practical importance of the subject is now greater than ever, and increases at a rapid rate.

It is not always possible to draw hard-and-fast lines of division between different kinds of water motors. Hydrostatics and hydraulics overlap in regard to their applications. If we attempt to distinguish between weight and pressure, we have already seen that the results of natural head are produced by pressure in the accumulator through the medium of pumps. Kinetic energy, or that due to velocity movement of a liquid, is obtainable from either head or pressure. Head is due to gravity, and the liquid is only the agent through which gravity acts. When we come to the methods of utilising water-power the differences in these acquire a practical interest.

Hydrostatic and Hydraulic Machines. The distinction between the hydrostatic and hydraulic machines may be put tersely thus: in the former the liquid has no energy of motion, but only that of pressure; in the second pressure is employed to produce motion, and the energy of the motion is that which is utilised for doing *work*. In strictness, therefore, the various so-called hydraulic engines belong to the same class as the press cylinder and rams, and not to the turbines and allied machines. They are so designed that with little essential modification they can be used for liquids and gases alike, a point we shall note in rotary blowers and centrifugal pumps. One of the best-known engines, the "Brotherhood" three-cylinder type, can be, and is, actuated by steam pressure, or water, or compressed air, as in torpedoes.

The capstans which one sees on quay and dock walls are often operated hydraulically by means of engines with oscillating cylinders, the pistons of which all drive on to the crank, which, being continuous with the shaft that operates the mechanism to which the engine is connected, drives it. In the capstan this shaft is the one to which the capstan head is attached. In some cases the "Brotherhood" three-cylinder type of engine is used, in others, four cylinders. The pressure water enters and leaves through passages in the cylinder trunnions. These passages are opened and closed by the oscillation of the cylinders.

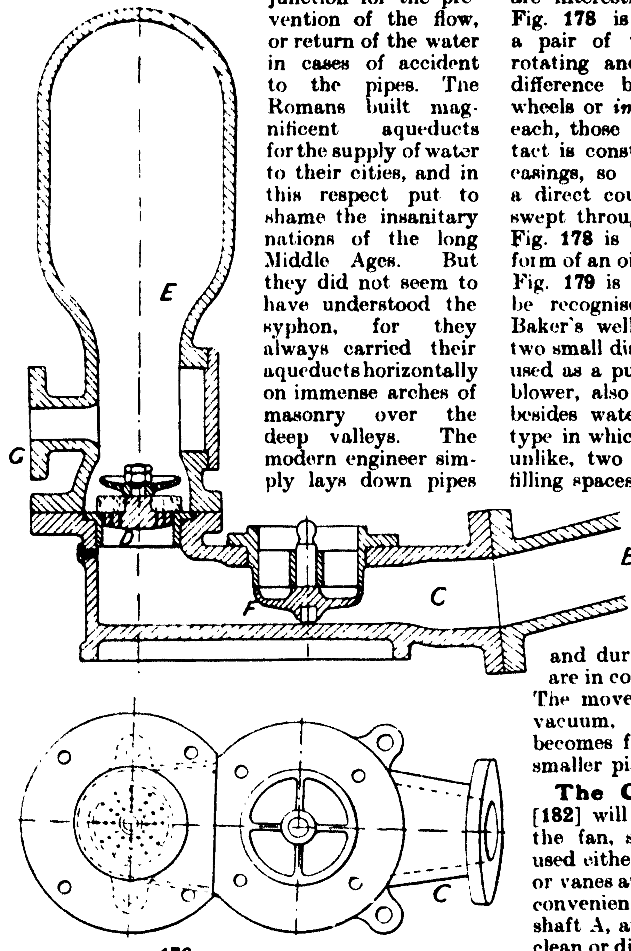
The Hydraulic Ram. This machine, which utilises the kinetic energy of moving water to raise a portion of that water to a very much higher level than the source of supply, is not a paradox. It does not contradict the law that water can only find its own level. The problem is not hydrostatic, but dynamic. Given a constant water supply, therefore, it would come near fulfilling the ideal of perpetual motion.

In this machine [176] water flows from a source of supply, as a pond or tank, A, under a head, coming through a sloping pipe, B, the *drive pipe*, into the ram. This consists of a casing, C, having two valves, and an air vessel. The valves are the check valve, or delivery valve D, opening into the air vessel E, and the dash valve, or door F, opening downwards into the casing, and dropping by its own weight. It comes between the source of supply and the check valve and air vessel to which the delivery pipe is connected at G, and which is connected to the cistern or other vessel which has to be supplied with water. The action is as follows.

How the Ram Works. When the valve (not indicated) which closes the mouth of the drive pipe at the feed tank end A is opened, the water flows down the pipe B into the ram C, and begins to escape by the dash valve F. But almost immediately the impact of the water on the under side of this valve lifts, and closes it, preventing any further escape for the moment in that way. The momentum of the water, thus arrested for a time, raises the pressure in the body of the ram, lifting the check valve D communicating with the air vessel E, and some of it passes into this vessel. Then there follows a recoil of the water into the drive pipe, which allows the dash valve F to drop, allowing some water to flow past it, and the cycle of operations begins again, and is repeated from 40 to 200 times a minute. At each movement a little more water is driven into the air chamber E, compressing the air therein, and being in turn ejected through the only outlet possible, that into the delivery pipe G leading to the storage.

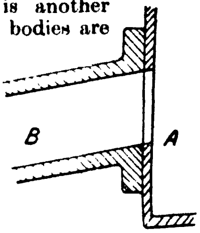
Advantages of the Hydraulic Ram. Thousands of these valuable little pieces of mechanism have been fitted in country houses, farms, and institutions where there is no public service water available. They are made in more than a hundred modified designs, only one of which is shown, to suit all kinds of conditions, until nearly all things are possible to the possessor of a suitable ram. It will work 24 hours a day with practically no attention. It can be made to work with large or small quantities of water, from 1 to 2,000 gallons a minute, and to suit falls of from 18 in. to 100 ft. Hydraulic rams are designed to raise from 300 to 500,000 gallons a day. Some of them will force water to 1,000 ft. in height. By comparison with other methods of water raising they show to much advantage. Windmills, water-wheels, pumps, engines, electric motors, all suffer from various disadvantages due to their greater cost and complication, besides which they all require more regular attention than rams do.

The Syphon. The syphon is not a mere toy, or a device utilised on a small scale by a gardener or plumber for emptying a tank or cistern. It is employed on an immense scale in bringing water supplies to cities. Only, in these cases the syphons are huge pipes inverted, and having numerous valves at certain points of junction for the prevention of the flow, or return of the water in cases of accident to the pipes. The Romans built magnificent aqueducts for the supply of water to their cities, and in this respect put to shame the insanitary nations of the long Middle Ages. But they did not seem to have understood the syphon, for they always carried their aqueducts horizontally on immense arches of masonry over the deep valleys. The modern engineer simply lays down pipes of cast iron or steel following the contour of the valleys, knowing that water will ascend in the endeavour to find the level of its head. The system is used in the American and Russian oil fields, as well as in numerous aqueducts, as the Croton, where a syphon passes under the Harlem River in the United States, and the Manchester-Thirlmere, the Birmingham-Welsh, the Liverpool-Vyrnwy, and other British water supplies.



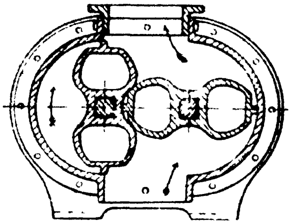
176. HYDRAULIC RAM

Chamber Gears. We must not pass without notice a group of mechanisms, which are more familiar in the form of blowers than of water pumps, and to which the term *chamber gear mechanisms* has been given. Roots' blower [177] is the most familiar form, but everyone does not know that this has also been employed as a rotary pump. Two two-lobed wheels revolve in contact with each other and within their casing. The lobed wheels or pistons being rotated in unison by an external source of power, propel liquids as well as gases. There are several types of these rotary pumps, of especial value for viscous liquids, and they are interesting studies in applied mechanics. Fig. **178** is a rotary pump which is simply a pair of toothed wheels of the gear type rotating and interlocking. Substantially, the difference between **177** and **178** is that the wheels or *impellers* in the first have two teeth each, those in the second have six. The contact is constant between the wheels and their casings, so that fluid cannot pass through in a direct course, but must occupy the spaces swept through by the rotating wings or teeth. Fig. **178** is familiar in machine shops in the form of an oil or suds pump for lubricating tools. Fig. **179** is a form used as a blower. It will be recognised as identical in principle with Baker's well-known blower, the latter having two small discs instead of one; and this has been used as a pump. Fig. **180** is a modified Roots' blower, also used as a pump for other liquids besides water. Fig. **181** is another type in which the revolving bodies are unlike, two teeth on one filling spaces in the other, and during the intervals the circular bodies are in contact. It is termed the *drum pump*. The movements of the two pistons create a vacuum, into which the water flows, and becomes forced out by the front face of the smaller piston.



The Centrifugal Pump. This pump [182] will be recognised also in the form of the fan, so that here, too, a mechanism is used either for liquids or gases. The blades or vanes are rotated within a casing, from any convenient source of power, coupled to the shaft A, and pump water and other liquids, clean or dirty, as there are no valves to become choked up. The same mechanism is used for dredging wet sand, gravel, and mud, just as the centrifugal fan is employed in extracting sawdust and shavings from woodworking machinery.

Fig. **182** represents a 52 in. pump by Tangyes, Ltd., the measurement being that of the discharge opening B. It is a double suction pump—that is, the liquid enters by two tubes, CC, diverging from a single pipe and opening into the pump at the sides, where the liquid develops kinetic energy by the revolution of the vanes D, and being discharged at the coned openings and passing round the volute-shaped casing E, escapes at B.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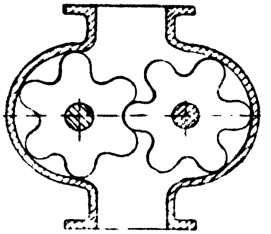
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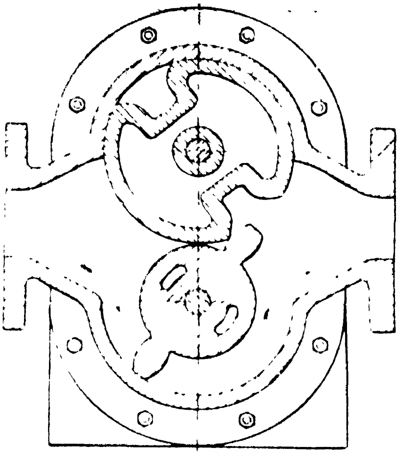
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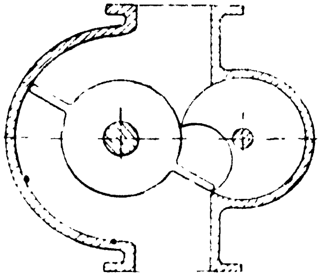
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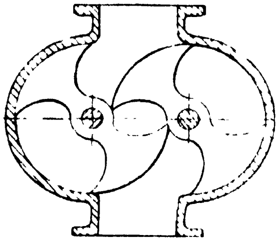
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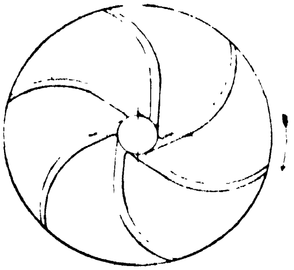
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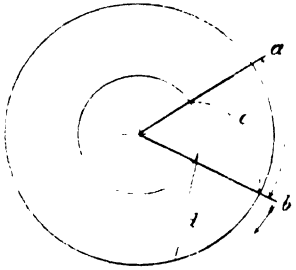

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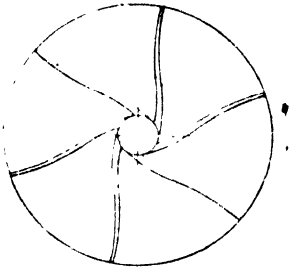
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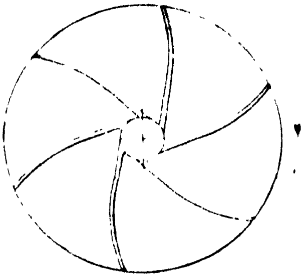
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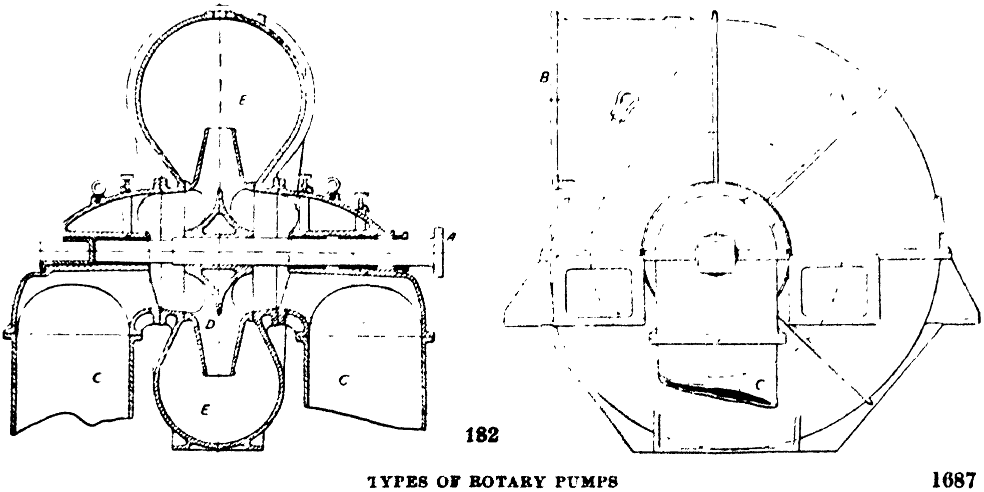
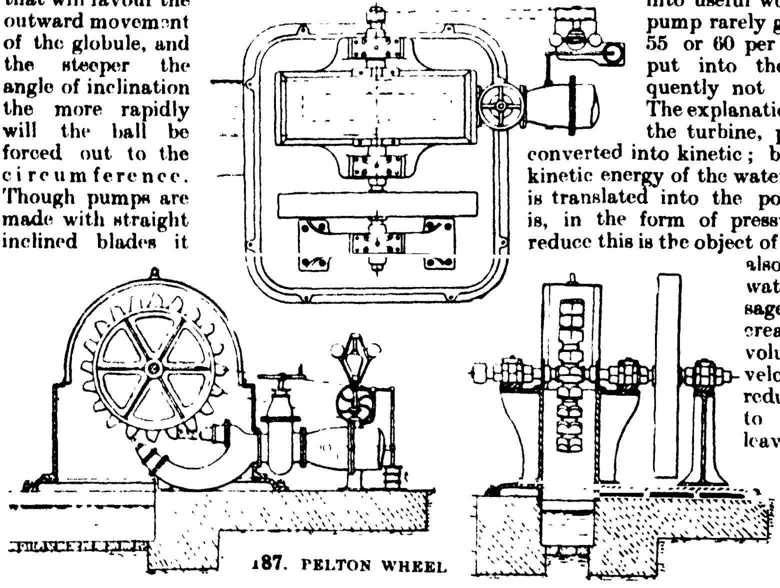


182

TYPES OF ROTARY PUMPS

Centrifugal Pump Blades. The blades or vanes are generally curved, because that is the form which is the most efficient in the propulsion of the liquid from the centre to the circumference of the casing. We shall meet with similar curves directly in turbine practice. High speed is essential in any case to the efficiency of these pumps.

The curves or the vanes are referable to radial lines, thus: if a rigid rod [183] revolves about a centre and carries a loose ring upon it, which we may suppose to be a particle of water, the ring will move to the end of the rod under the action of centrifugal force. But in doing so, the path which it describes will not be a radial one, but a component of radial and circular motion. In passing from *a* to *b*, the path taken by the globule will be that indicated by the dotted line *c*. If the rod be inclined away from the direction of rotation, as at *d*, that will favour the outward movement of the globule, and the steeper the angle of inclination the more rapidly will the ball be forced out to the circumference. Though pumps are made with straight inclined blades it is better to curve them, and the shape of the curve may be approximated by moving a pencil in a radial direction across the face of a revolving disc. It will be found that curves will be described resembling in form the vanes used in pumps, and the more rapid the rate of rotation the larger will be the amount of curvature or spiral developed. These, therefore, indicate the approximate forms of the vanes of pumps of this class, examples of which are given in **183** to **186**.

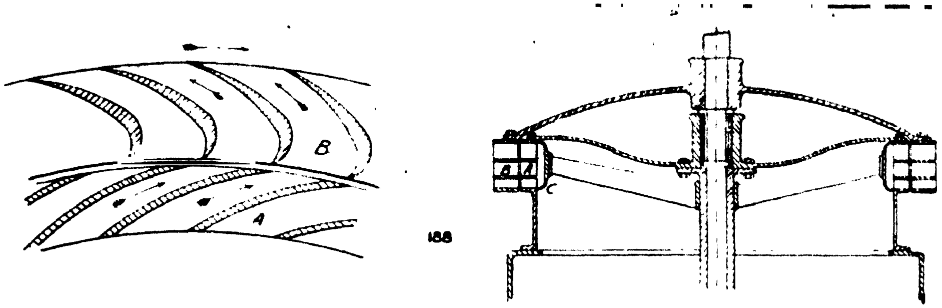

187. PELTON WHEEL

Curvature of Blades. It must not be imagined, however, that the determination of the most suitable curvature, or the question of straight inclined blades versus curves, is so simple as the foregoing elementary example would seem to imply. The whole subject bristles with difficulties, and the form of the volute, and of a whirlpool chamber in some cases has much influence on results. Only by much experimenting and experience have the pump manufacturers been able to produce the most efficient pumps for different speeds and heights of lift.

The real behaviour of a pump that is modified in design only slightly from previous examples has to be ascertained by experiment. Curious anomalies have come out sometimes. But the net result is that a given pump has some particular speed and height of lift which is its maximum possible. And it is found that there are limits below, as well as above, at which a pump will not work efficiently, though the latter case only is often accepted.

Mechanical Efficiency. The centrifugal pump is substantially the inward flow turbine reversed. That seems a very simple fact. Yet the mechanical efficiency of the pump is much less than that of the turbine. While the latter converts about 80 per cent. of the potential energy of the water into useful work, the centrifugal pump rarely gives out more than 55 or 60 per cent. of the work put into the shaft, and frequently not so much as that. The explanation offered is that in the turbine, potential energy is converted into kinetic; but in the pump the kinetic energy of the water leaving the vanes is translated into the potential form—that is, in the form of pressure or shock. To reduce this is the object of curving the vanes; also of discharging the water into guide passages of gradually increasing area, as the volute [**182**], until the velocity is sufficiently reduced. And, finally, to allow the water leaving the wheel to form a free spiral vortex in the pump casing.

Aim in Construction. In the construction of these pumps, as of turbine buckets, the object is to proportion the curves so that the water shall pass through with the least friction, and leave the buckets with as little velocity of movement as possible, because velocity means so much energy wasted. A secondary advantage of curved vanes is that as they permit of more slip between their faces and the water, they are more favourable to efficiency under a larger range in speed than radial vanes are. Experiments by the Hon. R. C. Parsons showed that invariably the efficiency of wheels with curved vanes was greater than that of those with radial vanes when the wheels discharged into a vortex chamber. It has also been proved that efficiency increases rapidly with the quantity of the discharge. Centrifugal pumps are coned in order to decrease the divergence of the streams passing through the pump, and so to reduce the residual energy.



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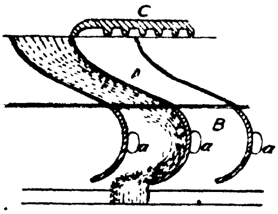

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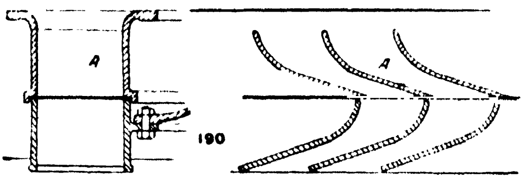

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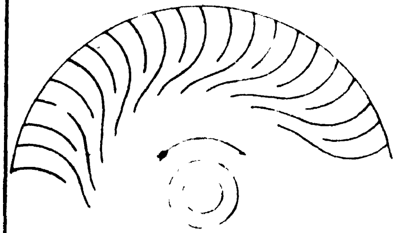

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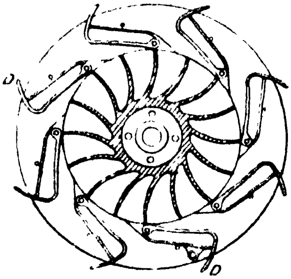

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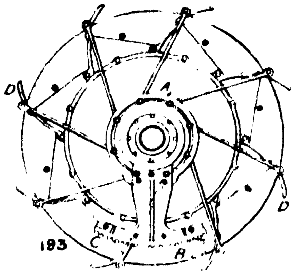

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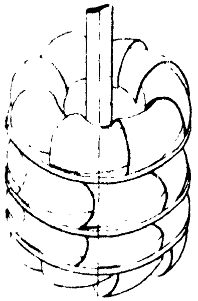

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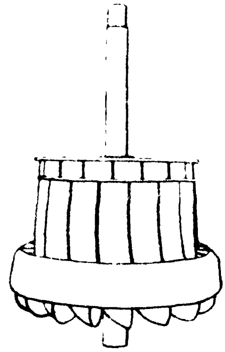

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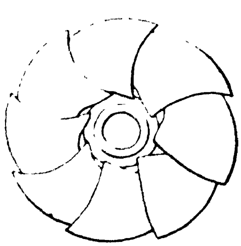

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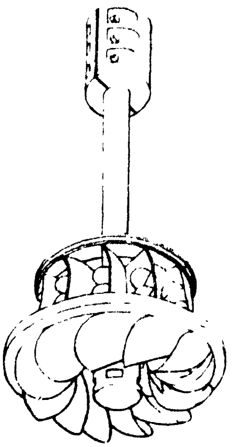

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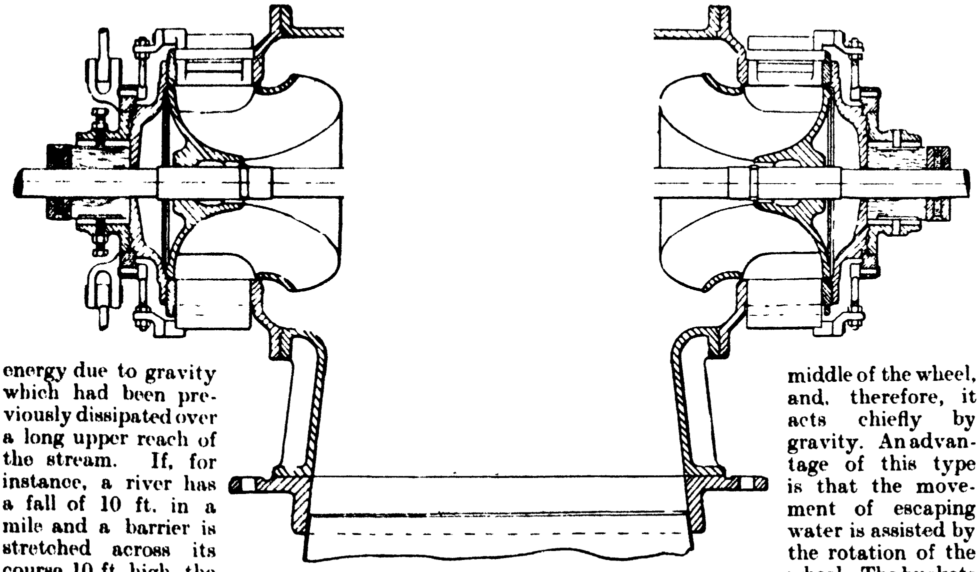
TYPES OF TURBINES

Water-wheels. These come on the border line of mechanisms that act by gravity and by kinetic energy. They act mostly by gravity—the turbines do so by energy of velocity. But in some forms of the water-wheel, gravity force develops into that of momentum, and in some forms of low-pressure turbine, gravity is the principal form of force. We shall, therefore, consider in brief the characteristics of the principal types. But first it will be desirable to show by what methods the potential energy of flowing waters is coerced and utilised.

When a stream is flowing, its rate of movement is slow or swift, according as its fall is slight or considerable. If it falls one foot in the course of a mile its movement is slow; at the other extreme we have the rapids, the cascades, or the cataracts. In each case there is potential energy present, but it is hardly, if at all, apparent in the first while obvious in the second. One can hardly realise latent energy in the Thames, but it is striking and grand in Niagara.

Value of Dams. But if we should dam the Thames, the potential energy of the stream would become apparent. When old London Bridge was in existence, the narrow arches dammed the water back so much that several feet of head was utilised for driving water wheels. The effect of damming is simply to raise the level of the water at that locality, and so concentrate at one place the energy due to gravity which had been previously dissipated over a long upper reach of the stream. If, for instance, a river has a fall of 10 ft. in a mile and a barrier is stretched across its course 10 ft. high, the water will drop 10 ft. sheer, and will give out the energy due to 10 ft. of head. This was the device of the old millwrights, who drove water-wheels by the power of gravity acting through the head of water.



198. FRANCIS TURBINE

Actually, 10 ft. is a rather low head, and requires a large volume of water to make it very efficient. At the other extreme, therefore, there is the cascade, many scores or hundreds of feet in height, but having its potential force broken up and dissipated on a series of rocky steps. But if it be enclosed in a chute or a pipe so that the frictional losses due to the broken waters are minimised, it becomes capable of exercising powers that are often measurable in that of many hundreds of horses.

The problem now becomes how best to utilise the *low*, and *high heads* as they are termed. An enormous amount of water motor engineering centres around these, but nearly all are capable of classification under water-wheels and turbines.

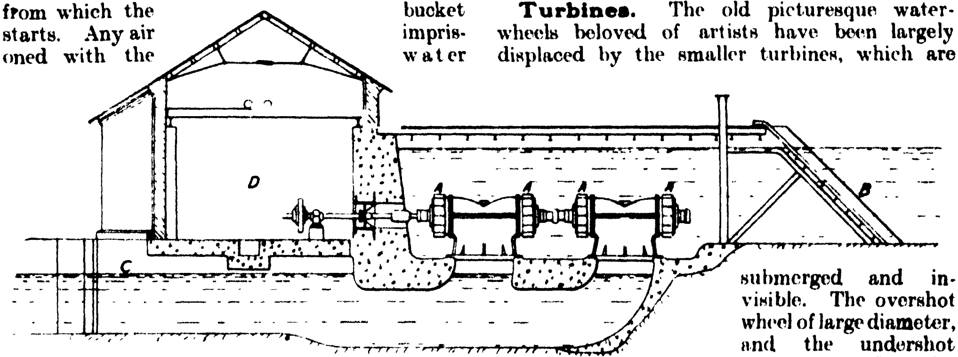
Water-wheels are classed as *overshot* when the water comes over, and nearly at the top of the wheel; *breast* when it comes between the top and centre, sub-divided also into *high*, and *low breast* wheels; *undershot* when the water comes at the bottom of the wheel.

Overshot Wheels. In these wheels the water is brought along a shoot—the *head race* above the wheel—and is discharged into the curved buckets immediately beneath. It is, therefore, essentially a gravity wheel, though, as the water must possess some velocity at the moment of discharge, that must be credited with a small portion of the results. The buckets are curved to retain as much of the water as possible before it is discharged into the *tail race*.

Breast Wheels. In these, water is introduced somewhere between the top and the middle of the wheel, and, therefore, it acts chiefly by gravity. An advantage of this type is that the movement of escaping water is assisted by the rotation of the wheel. The buckets are either curved, or facetted, to approximate to curved forms. Though the high breast wheel receives the water nearly at the top, it differs from the overshot in the direction in which the water is brought to it, being *against* the buckets instead of *over* them.

The Undershot Wheel. In this wheel we have what is really a connecting link between the water wheel and turbine, since the water does not act by simple gravity, but by its momentum, or kinetic energy, due to the head. There are two groups of undershot wheels—that with straight vanes and that with curved buckets, an important distinction which will form a text for the discussion of the forms of buckets in general.

When water impinges against flat vanes, eddies are produced which waste some of the power. By substituting curved vanes, with the concavity facing the water, the water runs up their faces, until arrested by the action of gravity, when it falls again. But it exercises pressure, and does work during both movements. This simple device of curving the buckets is applicable to all kinds of water wheels and turbines, and has been the subject of many formulæ. The original idea appears to have been due to Fairbairn, who substituted curved iron buckets for straight wooden ones. Another improvement due to him, applicable only to the overshot and breast water wheels, was the ventilating bucket—that is, a narrow space was left between the bucket and the rim of the wheel, from which the bucket starts. Any air imprisoned with the water in its descent escapes through this space into the bucket above, instead of occupying space that should only be filled with water, and so dashing the water out.



199. TURBINE DRIVE FOR ELECTRIC INSTALLATION

The Pelton Wheel. A water-wheel which is another connecting link between the gravity wheels and the turbines is the Pelton wheel. It is the best example of the impact wheel, pure and simple. A number of curved buckets are arranged around a disc, and a jet of water is driven through a nozzle against them under pressure. It utilises very low and very high falls, and also the force of the water pumped to a high pressure, as in the hydraulic power mains of cities. It is pre-eminently the water wheel for high falls, being adaptable for working at any heads from about 20 to 2,000 ft.; some installations exceed even this amount.

A great advantage of this wheel is its extreme simplicity of construction. A jet or jets of water are directed against the bucket, and slight variations in the dimensions of the tip of the nozzle, varying the volume directed against the buckets, render the wheels capable of working efficiently under varying water supplies. With low heads, large wheels with buckets of large capacity are required. The speed is determined by the head, but the diameter can be proportioned to speed required, and the number of nozzles can be increased to supply more water, or to obtain a higher speed than is obtainable by one nozzle.

Troubles of Turbines. Apart from these advantages, there is one fact that has more weight in some localities than in others. One of the troubles with turbines is the presence of leaves, sand, mud, etc., in the water, which chokes and scours the buckets; hence the need for the fitting of a grating or *forebay*, to intercept some of this injurious material. But the Pelton wheel, having open buckets only, discharges anything that comes in contact with them.

Fig. 187 illustrates a Pelton wheel installation for high falls by Messrs. Singrün Freres, of Epinal. It shows a device which is often fitted to these wheels—namely, two nozzles in place of one, so increasing speed. The governing mechanism and the sluice valve, the wheel covering, the tail race, and other details are apparent.

Turbines. The old picturesque water-wheels beloved of artists have been largely displaced by the smaller turbines, which are submerged and invisible. The overshot wheel of large diameter, and the undershot wheel of Poncelet type are the best, their efficiency nearly equalling that of turbines. But the breast wheels do not give more than half the efficiency of a poor turbine.

The water-wheel has its axis of rotation horizontal, and is a low-pressure motor. The turbine often has its axis of rotation vertical, and is a high-pressure motor. But there are some turbines with horizontal axes, and there are also low-pressure turbines. Generally, water-wheels are gravity wheels. Turbines are either *reaction* wheels, or *impulse* wheels. Besides this, they are classified according to the direction of entry of the water, as *inward flow*, *outward flow*, *axial*, and *mixed flow*. In all alike, water-wheels and turbines, the rotating wheel receives the water in buckets, blades, or vanes, by virtue of which the rotation is produced. The forms of these vary greatly, and slight differences in their curvature will often produce very important differences in efficiency.

Impulse and Reaction. It is now necessary to explain the difference between impulse and reaction turbines. The Pelton wheel [187] is an impulse wheel, and so, also, is an undershot water-wheel. Both these work in air. Yet there are impulse wheels which work entirely submerged in water, just as do the reaction, or *drowned* turbines. The difference, however, is that the submerged impulse wheels have what is termed *ventilating* buckets, or buckets having openings to permit free access of air thereto. The practical advantages of the latter are apparent when varying and small quantities of water only are available. These, with others, to explain which would lead us too far afield into the technicalities of this branch of engineering, render impulse turbines of greater value in some cases than the reaction types. The prototype of the reaction turbine may be noted in Barker's mill. Here two jets of water issuing under pressure from bent tubes on opposite sides of a suspended tube cause rotary movement in a direction opposite to that in which the tubes are bent.

Water Flow in Turbines. Any turbine is distinguished from a water wheel by having two rings of buckets or vanes, one ring containing guide vanes only, the other the buckets or the turbine proper. The function of the first is simply to bring the water at the most suitable angle into the latter, in order to produce the highest efficiency. The water may enter within the ring, and pass outwards, denoted by the term *outward flow*. Or it may enter from without, and pass away inwards, termed, then, *inward flow*. Or the water may pass through in a direction generally parallel with the axis of rotation—the *parallel*, or *axial flow*, group. Or the radial and parallel may be combined, as in the *mixed flow* turbines. Finally, the term *drowned* is applied to reaction turbines, and *ventilating* to the impulse kind. Each of these —the reaction and the ventilating—include the subdivisions previously stated, as denoting the manner of flow, and each is, further, of low and high-pressure classes.

The Fourneyron Turbine. Fig. **188** illustrates this, the oldest type of reaction turbine. It is of the outward flow class. The vanes and buckets are shown to the left and a vertical section to the right. A is the fixed guide ring, through which the water flows to the turbine wheel B, so driving the latter round, and being itself deflected by the curves of the buckets before discharge on the outside of B. The sectional detail to the right shows three sets of vanes, and buckets, separated by plates, the object of which is the regulation of the quantity of water passing through. This is effected by sliding the governor ring C to one, two, or all three sets of openings. As shown, the openings are all covered.

The Girard Turbine. This is an impulse turbine. It is generally of the axial type. Its leading features are as follow. Fig. **189** illustrates vertical sections through the guide vanes and buckets with the holes *a* in the latter for ventilation. The water enters the vanes A with the entire velocity due to the head, and thrusts against the concave sides of the buckets B without touching the convex sides. To permit of this the buckets are widened towards the bottom.

The governing of the turbine is facilitated by the fact of its being an impulse type. A sliding gate, C, can be regulated to close the ports of the vanes or guides in succession. The ports not covered are thus left fully charged with water. Neither is there any change in the angle at which the water enters. It is, therefore, eminently suitable for cases where there is much variation in the water supply, or where the amount of water used shall be in direct proportion to the power required.

Girard turbines, as described, are used for falls of water up to about 50 ft. For higher heads, a system of partial injection is adopted, the water being admitted only on a portion of the circumferences. In this way a speed not too high is obtained, which with full injection would require reduction gears. Generally, too, the shafts in high-fall turbines are set horizontally instead of vertically.

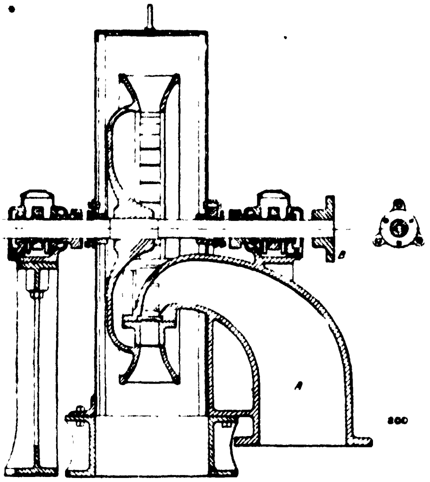
The Jonval Turbine. This, also, is of the parallel flow, or axial type, but it is a reaction or pressure turbine [**190**]. Its vanes, A, or *ports*, are closed, similarly to the Girard, by slides, not shown, for purposes of regulation. It is suitable for low and medium falls, and can be immersed in backwater, or raised above tailwater in a tail suction pipe, to a height not exceeding 25 ft.

The Vortex. A turbine termed the *Vortex* is of the mixed flow type [**191**]. The water enters from the outside and passes away at the centre, below and above the casing. The wheel belongs to that class which has movable or adjustable guide passages, not illustrated, by virtue of which the supply of water to the buckets [**191**] can be adjusted, so making the turbine capable of utilising reduced quantities of water in an economical fashion, since the water is admitted in any volume to the whole of the circumference of the wheel. The water supply comes through an encircling case. The width of opening of the nozzle of each guide blade is regulated simultaneously by means of levers and shafts, the blades being pivoted. There are four or more of these guide vanes in the circle. In cases where the quantity of water available and the power are constant, the guide vanes are *fixed*, since adjustability would have no advantages. This simplifies the construction.

The Leffel Turbine. This method of regulating the water supply by means of movable pivoted guide vanes is carried out in the Leffel turbines, and others modelled after them. Figs. **192** and **193** show this mechanism in sectional plan and in external plan respectively. The gates are operated from a central disc, A, which is moved by a pinion, B, and segmental rack, C. The levers seen pivoted to this disc regulate the amount of opening of the gates D. A fender opposite each gate relieves it of the pressure due to head of water, so that it can be moved readily.

Fig. **194** shows an improved form of wheel brought out by the Leffel Company, which they have christened the *Samson*. It is a double wheel, retaining the gates, not shown, of **193**. Each set of buckets receives its own separate quantity of water.

The Little Giant. This turbine is of the mixed flow type The water enters radially from without, and discharges axially. But the water enters into two sets of vanes, divided by a partition, and escapes through two sets at top and bottom [195 and 196]. These stand out from the sides of the wheel very much like cowls. It may, therefore, be described as a double turbine, in one casing ; the upper tier of buckets discharging at the top, and the lower tier at the bottom of the case. This turbine is well adapted for part gate working, or for those conditions in which the water supply is variable, and deficient in amount in dry weather. Regulation is effected by an iron division plate that passes horizontally through the turbine casing, and divides it into two compartments, corresponding with the two tiers of buckets. The water supply is regulated by a sliding gate which admits the water to both tiers of buckets, or to the lower tier only, according to whether it comes down to the division plate or not. The point to note is that the full pressure is maintained in the lower bucket, so that the efficiency is as high in proportion as when working at full gate, which would not be the case but for the division into two sets of buckets. It is of the drowned type, the tops of the upper buckets being about 3 in. below the surface of the water in the turbine pit.



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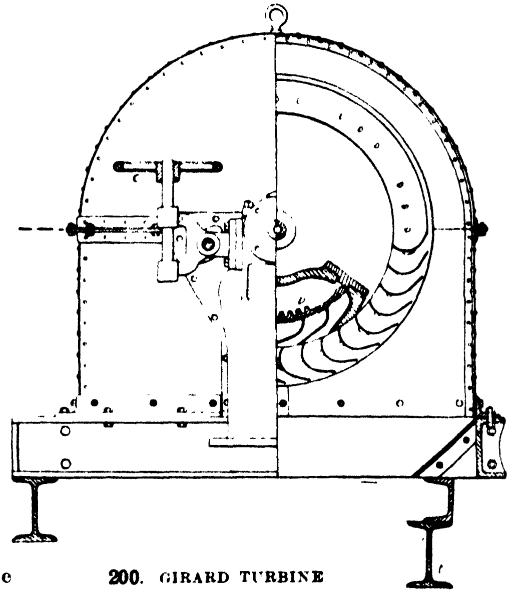


200. GIRARD TURBINE

The Hercules Turbine. This turbine, the wheel of which is shown in 197, is of the mixed flow class, inward and downward. It is of the regulating type, a cylindrical gate between the guide passages, and wheel opens or closes the rows of buckets. It is a reaction wheel.

The Francis Turbine. This is an old type, which has suffered from neglect until recent years. It has been revived, notably by the Swiss firm of Escher Wyss & Co., and the finest installations of this type are those of the Niagara Falls Power Company, and the Canadian Company. In the former, there are ten of these turbines of 5,500 h.p. each. In the latter, the turbines being laid down, three in number, are of 10,250 h.p. each.

The combination of radial and axial flow with the curvature of the vanes, which causes the water to leave them in a direction parallel with the axis [198], is the secret of efficiency. The point is that the radial flow is changed into the axial while the water is in the buckets, instead of after it has left them. In the latter case there would be kinetic energy still in the water, which means waste. Fig. 198 shows two Francis turbines, by Jens Orton-Böving.

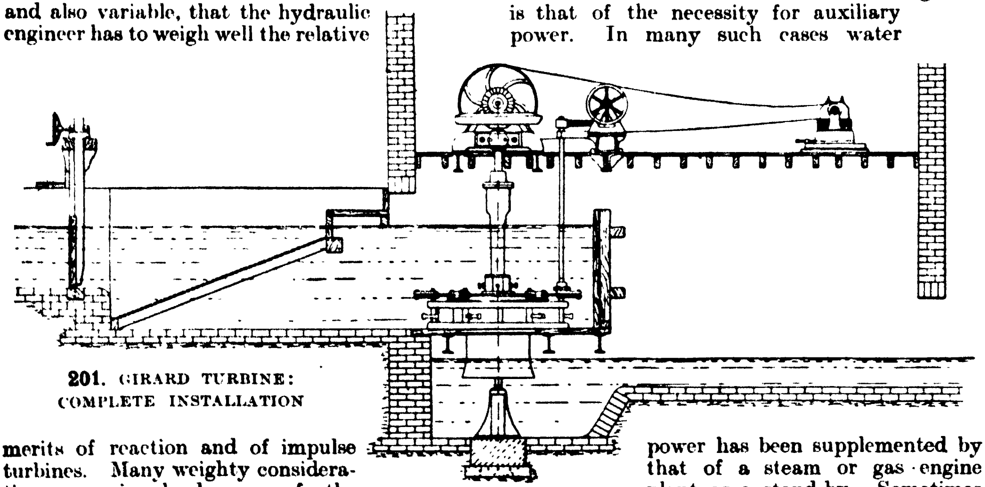
Advantages of Turbines. The story of the turbine, like many another piece of engineering, is one of development. The old Fourneyron, of sixty years ago, was a wonderful machine. The most successful machine of the present day is, in a sense, a Fourneyron reversed. The Francis is a radial inward flow turbine, the fixed guide wheel surrounding the movable wheel. Turbines may be single, double, treble, or quadruple, with corresponding increase of speed. A great advantage which the turbine has over a water wheel is that its axis can be set horizontally just as easily as vertically. It is a question of bringing in the water. This question has assumed great importance since the practice of coupling dynamos direct to turbine shafts has become so general. This is impossible with a common water-wheel, because the speed of revolution is never high enough for electric driving. Dynamos are coupled to vertical shafts, but it is preferable to have the shafts horizontal when practicable. Fig. 199 illustrates a turbine drive for an electric installation, by J. O. Böving. Here there are four turbines, A, A, A, A, driving on one horizontal shaft.

The objection to placing the axis of a turbine vertically is the difficulty of supporting the central revolving shaft in a suitable bearing. Another is that this position is not so suitable for direct driving of dynamos and shafting as the horizontal. Hence the reason why very many turbines have their shafts horizontal, as in 199, running in good bearings, and coupled direct to dynamos, or belted to machinery.

Water and Electricity. The potentialities of water power have been utilised to a far greater extent since the installations of electricity have come into existence. There are hundreds of thousands of horse power which could not have been enchained without the electric conductor as an agent of transmission to distant industries. In Canada, the United States, California, Switzerland, and Italy, France, Germany, Sweden, and other lands, rivers and falls which have run to waste for thousands of years, have, within the last ten years, been made to supply electric light and power. Gradually the distances of transmission have increased, until the 200-mile limit has been passed, and engineers now talk of 500-mile possibilities.

Water power has the advantage of being the cheapest power agency. It will give back from 70 to 80 per cent. of work, against, say, the 20 to 25 per cent. of steam engines, and 30 per cent. of gas engines. The limitations to distance no longer exist, as they did in the old days when belts and ropes afforded the only means of transmission.

Large and Small Water Supplies. There is no difficulty in dealing with a constant and large flow of water. Even efficient water wheels can be constructed for such conditions. It is when the fall is low and the volume small, and also variable, that the hydraulic engineer has to weigh well the relative merits of reaction and of impulse turbines. Many weighty considerations are involved, one of the principal of which is the problem of getting a turbine that will work satisfactorily at *part gate*, as it is termed. Another is the question of speed. The higher the fall, the smaller is the turbine, and the higher its rate of revolution. With low falls the turbines must be of larger radii, and they revolve more slowly. Then the question of the nature of the work they have to do must be considered.



201. GIRARD TURBINE: COMPLETE INSTALLATION

A high speed would be desirable in some cases, such as for driving dynamos, but for slow running machinery a slowly-running turbine is preferable to reduction gear. But a large turbine costs more than a small one, and, being heavier, entails losses by friction. Hence there is no one type of turbine which is adaptable to all conditions, and there is, as the present article shows, a wide range of choice, so that an engineer who understands his work can always, knowing the governing conditions, advise as to the best for any given case.

Turbine Economy. An important feature in turbine economy is the governing of the speed and power. To use more water than is necessary is wasteful, besides which speed must not exceed required limits. In water-wheels the supply is regulated by a gate in the head race, and the height of this, again, is under the control of a speed governor. In drowned or reaction turbines it is necessary that the buckets be full of water. In order to regulate the flow, the buckets are divided as we have shown, and the openings to each series can be closed with a sliding gate, so shutting off the water wholly from either one or two.

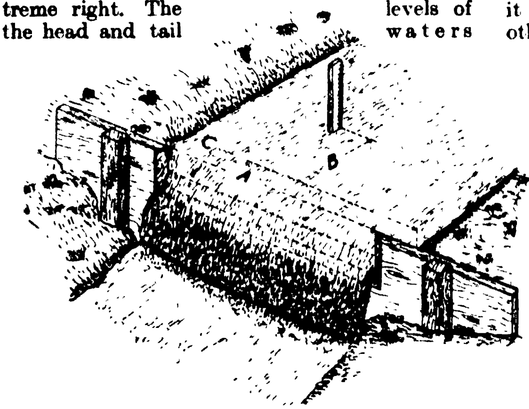
England is not a land of turbines, nor is she ever likely to be, because conditions are not so favourable as are those of more mountainous countries. Low falls, little head, and variation in quantity in winter and summer are not favourable to turbine driving. If there is a reasonable head, there is little water; if there is a flood there is little head.

A consideration which often arises in the choice of a turbine for low and fluctuating falls is that of the necessity for auxiliary power. In many such cases water power has been supplemented by that of a steam or gas engine plant as a stand-by. Sometimes this is necessary, but often it need not be if a suitable turbine, meaning by that one capable of working well in part gate, has been selected. Often, also, a storage pond could be employed, in which water might accumulate at such times as the services of the turbine were not required, as at night.

Girard Turbine. Fig. 200 illustrates a Girard turbine by Messrs. Gilbert Gilkes &

Co., Ltd., from which a very good idea may be gathered of the mechanical details of construction. It is of the same type as the buckets shown in 189, and is, therefore, an impulse turbine. The inlet pipe is seen at A, and the shaft is horizontal, and therefore a dynamo can be directly attached to the coupling B. C is the handle for regulating the gate D.

Fig. 201 shows a complete installation by the same firm. The turbine has a vertical shaft with a suspended form of bearing—a design which is largely displacing the old footstep bearing. Here the drive is through bevel gears and belt to the dynamo seen at the extreme right. The levels of the head and tail waters are evident, and also the forebay or strainer to the left, and the regulating sluice immediately in front of it. The regulating mechanism for the gates is seen to the right of the turbine, operated by a hand wheel at the top. The brick linings, timber frames, and timber and steel joists, with other details, are apparent.



202. FINDING QUANTITY OF WATER IN MOTION

Horse-power. To find the horse-power of water in motion, multiply the quantity of water in cubic feet per minute by the weight of a cubic foot = 62½ lb., and by the height of the fall in feet, and divide the product by 33,000. This is only the theoretical power. Of this a good turbine will utilise 75 to 80 per cent., and water-wheels, the breast type excepted, from 50 to 60 per cent. The height is measured from the level of the water in the head race to the level of the water in the tail race. Another method of reckoning the power of water is that used in California and termed the *miner's inch*. It denotes the quantity of water that will flow in a minute from an orifice 1 in. square under a head of 6 in., and is equal to 71½ cubic ft. per minute. Tables are prepared based on this. The quantity of water in cubic feet is measured by a notched board set across the stream as follows.

A length of from 50 to 100 ft. is selected, as uniform in section as possible, and its area of section is obtained by multiplying the average width by the average depth. A stake is driven at each end of the length selected, a float thrown into the middle of the stream a little above the first stake, and note is made of the exact time it occupies in passing from one stake to the other. This should be repeated several times to obtain the average speed. A bottle partly filled with water to float upright, or a piece of wood are suitable floats.

To find the quantity of water passing, the sectional area of the stream is then multiplied by the length taken, and by 60, and divided by the time taken in seconds by the float in passing over the measured length. A deduction must be made for loss due to friction at the bottom and sides of the stream, which may be taken at about 20 per cent.

Notched Board Measurements. Another method is that of a notched board or tumbling bay [202] placed across the stream to pass a given quantity of water over the notch, so forming a weir. The notch may be of any depth, but the lower level of the water should be at least a foot below the bottom of the notch. Its width, A, is about two-thirds the width of the stream, C. The bottom of the notch in the dam must be level. The dam should be of sufficient height to produce a still reach of stream above, so that the water shall flow over without appreciable velocity. A stake is driven near the bank for convenience in taking measurements. It must be far enough up the stream, B, to be unaffected by the curvature of the surface of the water passing over the weir, say 6 feet. The edges of the notched board are bevelled on the down side to nearly a sharp edge. When the dam is placed in position and the water obstructed thereby, the height to which the water rises up the stake indicates the depth of water flowing over the weir. When the water has ceased to rise above the weir, the depth from the surface to the top of the stake is measured. The width and depth are the data from which the quantity of water in cubic feet per minute are obtained from weir tables.

Continued

Group 27

TYPEWRITING

2

Continued from page 1529

TYPEWRITING PRACTICE

Spacing. Correspondence. Headings. Tabular Work. How to Set Out Addresses. Carbon Work. Manifolding

By MARGARET LILLIE

IT is now time that the student should begin to apply the principles which have been laid down. The only way to master the keyboard is to pick out the letters, striking them one by one, from A to Z, until the exact position of each is quite familiar.

Then should follow the practice of words, remembering that each letter must be struck firmly and evenly, and that prefixes like "ly" and "ing" should not, because of their familiarity, be hurried so that one letter prints unduly near the next.

The necessary space between each word is obtained by striking the space bar, which moves on the carriage—in most machines—the distance of one letter, and the paper is then in position to receive the next impression.

When the student has thoroughly mastered the keyboard, he should begin to practise such exercises as the specimen letter given on this page.

```
                                   26th January 1906.
Messrs. Brandon & Webb,
        107, Broadway Mansions,
             London, E.C.

Dear Sirs,
             We have to acknowledge receipt of
your favour of the 24th inst., and are very
sorry that you should have any cause for
complaint with respect to the delivery of
the goods which should have reached you on
the 19th inst.
         We will have the matter looked into
without delay, and write you further.
                        Yours faithfully,
                              BRANDON & WEBB.
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The word "Messrs." should be typed some little way in from the margin of the paper, the margin "adjuster" for most purposes being set on space 5.

Spacing. This brings us to the question of "spacing." If the student turns to the front of his machine he will find a scale which consists of spaces, each corresponding with the width of a letter. These little spaces are divided up into groups of five, and numbered in tens.

This scale corresponds with the one behind the roller, so that if the student wants an ordinary narrow margin, as in general correspondence, he slides the little "margin adjuster" along the back rod until it is on 5. For other classes of work, he will require a wider margin, in which case the adjuster may be set on 10, or, for foolscap work, on 15.

It sometimes happens that the operator may want to add an occasional figure or reference in the left-hand margin, and, by a simple arrangement which is fixed to nearly all the latest patterns, he is enabled to do so, without losing time, by touching a lever fixed to the carriage. By this same stop he is able, if necessary, to write a letter or two beyond the regular right-hand margin. This is useful when a word which is difficult to split up into convenient syllables happens to fall at the end of the line.

Special care should be given to the right-hand margin. It is obviously impossible always to avoid a broken appearance, but occasionally, by careful judgment in the division of words, much may be done to improve the look of the page.

Punctuation Marks. After a full stop, an exclamation, or interrogation mark, three spaces should be left; after a semi-colon or colon, two spaces; after a comma, one. Brackets should be divided from the rest of a sentence by one space before and one after; but there should be no space between the brackets and the words they enclose.

Let us now return to our letter. Having started "Dear Sirs," on 5, we should begin the word "We" on the line below, immediately following the comma. This is merely for the sake of appearance; all subsequent paragraphs begin on 10, the words "Yours faithfully" starting on about 35.

When a new line is wanted, the "line-spacing lever" is pushed up, and the carriage shifted back to the margin, which introduces us to another kind of spacing—the spacing which fixes the distance between lines.

In the majority of cases a letter should be written in "double" spacing. Most machines are arranged for three kinds of line spacing—single, double, and triple, which is determined by a simple arrangement at the side of the roller, varying with every make of machine.

Double spacing is generally used for correspondence, although some people prefer the close (or single) spacing adopted by many American firms. In this case, it should be remembered that the somewhat cramped appearance of the page is very considerably lessened by leaving a double space between paragraphs.

Correspondence. But we have so far dealt only with the actual body of the letter. We have still to consider the date and address. The former should begin on about 50, and the name and address, which may come either at the beginning or end of the letter, starts on 5, each of the following lines being indented five spaces.

In displaying the wording on the envelope, the student must exercise discretion, as the effect necessarily depends on the length and style of the address. In such an address as

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Llewellyn Baumer Esq.,
          37, Albany Road,
                    Hampstead, N.W.
```

each line is indented about nine spaces, although in the case of a long address single spacing should be used, and the steps closed up a little more to prevent a straggling appearance.

```
Mr. William Dimsdale,
     Dept. 7,
          The Roxburgh Printing Co.,
               Wellington Road,
                    Bournemouth, W.
```

In such an address, an indention of five spaces in each line is quite sufficient for display. Where, as in this case, a very short line comes between two longer ones, it should be centred.

An address of two very unequal lines should be written in this way:

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Messrs. Johnston & Turner, Ltd.,
              YORK.
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If ordinary envelopes are used, the flap should be opened out before inserting it in the machine, to get as even a surface for the type as possible. Of course, the best results are obtained by using those with square flaps, which are specially made for this purpose.

Mistakes. Although it should be used as little as possible, it is perhaps as well to assume that the student may occasionally have to resort to the eraser. For a serious error, it is very often the wisest course, and in the long run the quickest, to tear out the sheet and start again. Where this cannot be done, a piece of the special typewriter eraser which can be bought at any stationer's—the round pattern with the little metal disc is by far the best—should be used. The student should never attempt to erase a letter from a sheet of thin paper which is not protected from the roller by a "backing" sheet. It is important that such a sheet—any paper of a fairly thick substance will do—should be placed next the roller when foreign or thin paper is used.

The rubber is used *across*, and not *down* the paper, so that the faint smear, which it is almost impossible to quite get rid of, is hidden by the words on either side.

In a very few cases it is allowable to write *over* a letter. An *e*, for instance, may be written over an *o*, a *t* over an *i*, an *o* over a *c*, and so on; but this should only be done where the correction is not apparent.

When writing at high speed the space between two words may sometimes be forgotten, which will quite spoil the effect of a page. Many people are content to run a line through to divide them, either using the shilling mark, which is bad, or a pen, which is worse. Nothing spoils a page of typewriting so much as an ink correction. A far better way of getting out of the difficulty is to rub out the last two letters of the first word, pull the paper along half a space, write one letter, pull it along the same distance, and write the other letter, thus getting three letters within the space allowed for two. This needs practice and a nice judgment, but the effect is worth the trouble.

Centring. Where it is necessary to "centre" a heading, the number of words—including the space between each—should be counted and subtracted from the number of units on the scale bar [72] *minus the margin*, and the result halved. Then add the margin, and you have the exact figure on which to start the line.

In other words, find out the number of spaces your heading takes (say 30), subtract it from the *actual working line* (62—we will assume a margin of 10), and you have 32. Halve it, (16); add the margin (10), and 26 is the number on which to begin the heading.

If it is remembered that the heading has to come *in the centre of the typewritten manuscript*, the calculation becomes quite simple. In the case of a second heading following immediately below, the bottom line is sometimes improved by being spaced out, especially if both lines are of equal length. One space should then be left between each letter, and *two* between the words, as in

```
    SELF EDUCATION
K E Y  T O  S U C C E S S
```

Tabular Work. For setting out columns of words or figures, the quickest way is to type out the top lines on a rough sheet of paper, see exactly how best to arrange the columns, and make a note of the numbers on which to begin each set of figures.

Supposing one has to type five sets of figures to the line, it is quite easy to divide the columns up equally and remember to start the first letters of each on 5, 20, 35, 50, 65. It also avoids the necessity of lifting the carriage repeatedly, which obviously wastes a considerable amount of time.

Tabulators. Where a great deal of this class of work has to be done, it is desirable to have a device which is known as a "tabulator" fixed on to the machine, which automatically shifts the carriage from one fixed point to another without the use of the space bar.

Position. It is important that the operator should be seated comfortably. The correct position is that in which the elbows of the typist come about level with the keyboard. If possible one of the tables specially designed to hold typewriting machines should be used. The chair, too, should receive consideration. Those with a small, hard seat, and a straight back are most comfortable. Where much copying from manuscript has to be done a "copyholder" is a great comfort. It saves unnecessary bending, and if placed *behind* the machine, does much towards preserving the eyesight.

For the figure 1, the small "l" is used, and, for the nought, the capital "O."

CARBON WORK

When two or more copies of a page are wanted, a "carbon" is placed between each sheet, so that the shiny surface touches the page on which the impression is to be made. Great care must be taken in arranging the pages to see that some of the sheets are not reversed, or the result will not be a happy one. The surest way to avoid this is to lay the typewriting paper before you, heading upwards, and place the carbon so that the shiny surface covers it; then the next sheet with the heading up and carbon face downwards, and so on.

Thin paper must be used for this work, with the exception of the bottom sheet, which, to get the best results, should be of thicker make.

The keys should be struck very sharply for carbon work, and care taken to avoid handling the sheets more often than is absolutely necessary, as even the best makes are liable to smudge.

Erasures in carbon work should not be made in the usual way, or the preparation on the surface of the carbon will smear. The best way to remedy an error is to turn back the roller a little, insert a piece of paper between each carbon sheet and the writing, and rub out the wrong letter on each sheet separately. The slips of paper can then be removed, and the letter or word re-typed. But the operator must be careful that in turning back the roller the "pad" is not shifted.

If a faint, dark impression appears on the sides of the copies when the work is taken out of the machine, it is probably due to the fact that the little rubber clips which hold the paper firmly to the roller have not been pushed back.

MANIFOLDING

It is sometimes necessary to take 50 or 100, or more, copies of a single sheet of typewritten matter when there is not time to type each page separately. The process by which this is effected is known as *manifolding*.

The method is very simple, and easily explained. In the first place, the ribbon has to be removed, or, in some machines, merely put out of gear. The words are then typed on to a wax sheet, which, being soft and impressionable, receives the perforations of the type letters. Through these, by means of a duplicator (which may be purchased for about £2), the ink passes, and so leaves an impression on the paper.

Method. When the student has removed the ribbon, and seen that the type is perfectly clean, he should take the yellow oiled sheet from the roll supplied with the machine, and place it in the centre of the wax. Fold over very carefully the top and the sides, and then place over them the tissue sheet (which is merely to protect the wax), and turn in the top edge slightly to prevent its slipping when it is put in the machine.

As in carboning, the rubber clips on either side of the roller should be removed.

Then put the pad you have made into the machine just as if you were feeding an ordinary sheet, so that the impression is made directly on the tissue sheet. The matter must be very slowly and carefully typed, as mistakes are not easy to rectify. The keys should be struck evenly and smartly, but the "o's" must have a lighter depression, or the centre of the letter will fall out when the wax sheet is removed, and cause the ink to make a blot on the paper.

Mistakes may be erased by means of a special varnish, but it takes some little time to dry, and should, therefore, only be used as a last resort.

When the matter is typed, take away the oiled sheet, and then, very carefully, the tissue, which will need careful handling to prevent the surface of the wax being spoiled. All that we are concerned with now is the wax sheet, or "stencil," which is placed, face upwards, on the duplicator and covered with the "flimsy." Unfasten the steel frame, place it *under* the wax sheet, and then, with the sheet round it, lift it and fix it back into its place at the top of the apparatus.

The stencil must be very carefully adjusted. When in position it should be stretched as tightly as possible without tearing it. It must also be remembered that the least crease or crack on the wax sheet means an undesirable perforation, and so renders it unusable.

Now turn to the slate, on which enough ink should be squeezed to make a thin paste when rolled out, and evenly distributed. Next lift the upper part of the machine, cover the "baseboard" with blotting paper, replace the former, and pass the ink roller firmly over the stencil.

Pass the roller backward and forward until the impression is seen plainly on the blotting paper, which should be renewed two or three times until every letter is quite clear.

Then the sheet on which the impression is to be made can be put over a clean piece of blotting paper, and as many impressions rolled off as necessary. From a carefully prepared stencil, 300, or more, copies may be taken.

Two points should be remembered. In typing matter for manifold work see that each letter is struck with a uniform force; and use only just sufficient ink on the roller to give a clear, sharp result.

The process which has been described applies particularly to the "Ellam's" Duplicator. If, however, the "Roneo" is to be used, practically the same instructions apply, as in both cases a stencil has to be prepared.

Continued

STRENGTH OF SUNDRY MATERIALS

Hemp and Wire Ropes. Chains. Wire. Yarn Fibre. Leather Belting. Glass. Indiarubber. Pitch. Bolts and Nuts. Springs. Pipes

Continued from page 1523

By Professor HENRY ADAMS

Strength of Hemp Ropes. The average strength and other important particulars of round ropes may be tabulated as follows, where C = circumference in inches, W = weight in pounds per fathom, D = diameter in eighths of an inch.

Breaking weight of new rope in cwts. = $C^2 \times$ 4 to 5.
Safe load on new rope in cwts. = $W \times 3$
B.W. new stretched rope in cwts. = D^2.
Safe load stretched rope in cwts. = $W \times 4$.
Safe load new rope fall in cwts. = C^2.
Safe load good rope fall in cwts. = $C^2 \times \frac{2}{3}$.
Safe load sound old fall in cwts. = $C^2 \times \frac{1}{2}$.
Weight of clean dry ropes per fathom in pounds = $C^2 \times \frac{1}{4}$.
Weight of tarred rope per fathom in pounds = $C^2 \times \frac{1}{3}$.
Minimum diameter of sheave in inches = C + 2.

Varieties of Ropes. Small ropes are slightly stronger in proportion to their sectional area than large ropes. Manila rope varies from 10,000 lb. per sq. in. net section ultimate strength for a 2 in. diameter rope to 12,000 lb. per sq. in. for a ½ in. diameter rope, the net sectional area being about 81 per cent. of the circumscribing circle. Flat ropes are sometimes used with a width of about four times their thickness; their breaking weight in tons is equal to their weight in pounds per fathom, and their weight in pounds per fathom is approximately twice their circumference in inches.

Italian hemp ropes are said to be stronger than those made of Russian hemp. New white ropes are stronger and more pliable than tarred ropes, but the latter retain their strength for a longer period, owing to the protection afforded against atmospheric influences. Ropes are always stiffer after resting. A wet rope, or one saturated with grease, loses half its strength. A remarkable property of ropes is the extent to which they swell and shorten when wetted; practical use may sometimes be made of this property, but it more often acts detrimentally. All ropes should be kept dry and free from lime. Old ropes should be used with caution, for while they may still look sound, they may have very little strength.

Rope Driving. The power that a rope will transmit depends upon the velocity with which it travels as well as the force it transmits. A cotton rope 1¾ in. in circumference, weighing 1 lb. per foot, and running at a velocity of 5,000 ft. per minute, will transmit 50 indicated horsepower. Ropes of this kind are used in some workshops for driving overhead cranes, but they are now being generally replaced by electric driving. Hemp ropes are used for transmitting power from steam-engines to winding drums for cable tramways; the velocity is less, but the tension is greater than in the case of the high-speed cotton rope. The approximate horsepower of a hemp rope is found by multiplying the circumference in inches by the diameter of driving pulley in feet and by the revolutions per minute and dividing by 200.

TESTS OF ROPES.

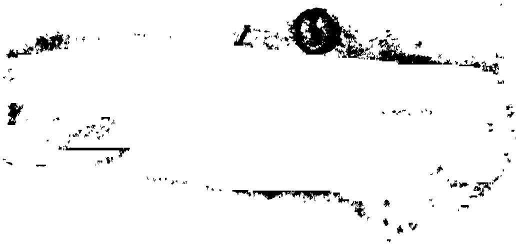
	Ultimate Tons per sq.	Elongation. Per cent.
White hemp ..	4·75	18
Tarred hemp ..	3·5	
White manila ..	4·5	15
White aloes ..	2·5	
Esparto and cocoa fibre ..	1·0	
Flat ropes, hemp or manila tarred	3·5	

Leather Ropes. Leather ropes of square or V section are used in connection with some electrical machinery, running in a V groove, and will transmit 320 lb. per sq. in. of section. Hide ropes are used sometimes for hand-power cranes, being steeped in Stockholm tar to prevent destruction by rats.

Wire Ropes. Wire ropes vary both in material and manufacture. Steel, owing to its greater strength, has entirely taken the place of iron for ropes. The ultimate strength in tons per sq. in. of the material itself, tested in single wire, as given by J. Bagshaw & Sons, of Batley, is: Bessemer steel, 45 tons; crucible steel, 56 tons; patent steel, 75 tons; and plough steel, 111 tons. The approximate breaking weight of the finished rope in each material will be the circumference in inches squared and multiplied by 1·5, 2, and 3·5 respectively, the working load being one-tenth of the breaking weight.

The life of a wire rope depends very largely upon the diameter of the sheaves over which it runs; for slow speeds, the diameter of drum should be 80 times the diameter of rope, but for high speeds of 30 to 50 miles per hour the drum should be 240 times the diameter of the rope. Some experiments by Sir Benjamin Baker at the Forth Bridge showed that with a diameter of pulley of only six times the diameter of rope, failure commenced after 5,000 bends, and was complete at 15,000 bends. When the diameter of sheave was increased to eight times the diameter of the rope, failure commenced at 10,000 bends, and was completed with 30,000 bends, these numbers bearing only a very small ratio to those required in practice.

Testing-machine for Ropes. A convenient machine for testing hemp or wire ropes, by W. & T. Avery, Ltd., Birmingham, is shown in 101. It is specially designed for proving wire and hemp ropes at any part of their length without destroying the ropes, and in addition for testing specimen lengths of rope. For proving up to a specified strain a rope afterwards to be used, the rope is passed through the gripping dies without being cut, and the section between the dies is proved up to the desired strain. Any number of such sections can be proved without destroying the rope, which is invaluable for insuring the safety of rope in use, or intended for use. For testing the breaking strain, a section of the rope is cut off and tested to destruction. The machine is entirely self-contained, the pressure being supplied by means of a hydraulic hand-pump carried under the frame, and the whole machine is mounted on four wheels, the front pair of which are made to swivel to facilitate removal from place to place. The strain applied is indicated on an automatic dial, the ultimate strain being marked by a loose registering finger. A graduated elongation scale indicates the extension of the specimen under test.



101. MACHINE FOR TESTING ROPES

Strength of Chains. Chains used for lifting loads are made of wrought iron, in plain oval links, the length over all being about 4⅝ times the diameter of the iron from which they are made, and the width 3½ times. They are known as "best tested short link crane chains." The oval form causes each link to act as a very stiff spring, and minimises the shock from too sudden a lift, or a surging of the load. The following table from the writer's "Handbook for Mechanical Engineers" gives a summary of the strength of chains:

STRENGTH OF CHAINS.

d = diameter of iron in ⅛ths of an inch.
Or if worn, diameter of smallest part.

B.W. in tons, B.B. short link crane chain	$\frac{1}{2}d^2$
B.W. in tons, ordinary chain	$\frac{2}{5}d^2$
B.W. in tons, ordinary chain (Anderson)*	$\frac{3}{8}d^2$
Elswick test in tons, 10 per cent. above Admiralty proof	$\frac{33}{160}d^2$
Admiralty proof strain in tons	$\frac{3}{16}d^2$
Safe load in tons (Molesworth, 11th ed.)	$\frac{1}{8}d^2$
Safe load in tons (Molesworth, 21st ed.) . .	$\frac{1}{9}d^2$
Safe load in tons, common rule	$\frac{1}{10}d^2$
Maximum temporary load on good annealed chain in cwts.	$2d^2$
Safe load, ordinary chain (Anderson), in tons	$\frac{3}{35}d^2$
Safe load, for ordinary cranes, in cwts.	$1\frac{3}{8}d^2$
Safe load, for coal cranes, in cwts. . .	$1\frac{1}{4}d^2$
Safe load, old chain, quality and condition unknown, in cwts.	d^2
Weight in pounds per fathom, short link crane chain	d^2
Weight in pounds per fathom, ordinary crane chain	$\cdot 88d^2$

* This is known as the "Statute breaking stress."

Iron with the mark (Crown SC) breaks with an ultimate stress of 26 tons per sq. in. A $\frac{9}{16}$ in. chain should therefore break with a load of 13 tons, but a test piece 4 ft. long usually breaks with a load of 9 to 10 tons, generally opening at the welds. These chains are tested before use with a maximum load of 4½ tons, and used on coal cranes to lift a gross load of 1¼ tons. Under these conditions, a good chain, properly looked after, will make from 100,000 to 150,000 lifts before it is worn out. It may occasionally fail in use although so large a margin for safety is adopted

Chain-testing Machines. It is usual to test new chains for proof strength in successive portions up to 30 ft. long each in such a machine as 102, by W. H. Bailey & Co., Ltd., of Manchester, and then to examine them afterwards very carefully link by link to see that no welds have opened, and that no other flaw due to bad workmanship is shown. The machine consists of a strong girder frame with a hydraulic pulling cylinder fitted at one end. The cylinder is worked by means of a hand-pressure pump, or it can be coupled direct to hydraulic-pressure mains. A gauge is provided on the cylinder for indicating the strain on the test length of chain. Old chains are sometimes tested in a machine, but this is a dangerous practice, as they may be strained beyond the elastic limit without showing any external evidence of damage, and then fail in work from no apparent cause It is much safer to pass old chains through an annealing furnace and then examine each link carefully over the point of a smith's anvil. This at least is the writer's view, based upon a very wide experience in the practical use of crane and lift chains.

A 4 ft. length of chain from each batch of new chains should be tested to destruction to prove the ultimate strength and the quality of the workmanship.

Testing Wire. It is well known that a metallic wire will withstand a much greater intensity of stress than a bar or plate of the same material. This is no doubt owing to the effect of drawing it through the dies in the process of manufacture, which tends to increase the length and reduce the sectional area of any inferior portion which may be mixed up with the other, so that a better average will result.

Wire-testing Machine. A suitable machine, by W. & T. Avery, Ltd., for testing either small or large wire is shown in 103. It may be used for ascertaining the breaking strain and elongation of wire, metal strips, cycle spokes, small specimens, etc. The strain, up to a maximum of 7,000 lb., is applied by worm and wheel gearing actuated by a hand-wheel, and is indicated in single pounds on the steelyard by a sliding poise with revolving graduated dial. The steelyard is balanced entirely by the sliding poise, thus dispensing with the use of loose weights. The sliding poise is moved along the steelyard for balancing by special gearing connected with a small hand-wheel fixed on the frame of the machine, which ensures a continuous steady strain, giving absolutely accurate results. This is a great improvement on the old hand method, as it is impossible to put the strain on suddenly. Quick return of the die-box after fracture of the specimen is ensured by an instantly operated arrangement of change wheels. A graduated scale is provided for recording the elongation of the specimens. The two hand-wheels are conveniently arranged so that specimens can be tested by one operator. Sets of dies are supplied to suit various gauges of wire, and by means of these the specimens can be speedily and effectually gripped.

Testing Yarn and Fibres. There are many instances where it is desirable to ascertain the strength of fibre, and something lighter and more delicate in construction than the machines already described is necessary. A very convenient yarn-testing machine, by W. & T. Avery, Ltd., is shown in **104**. It is designed to ascertain the breaking strain and elasticity of all kinds of yarn, etc. It is fitted with ratchet quadrant and positioning pawl, which engages the poise in its exact position at the moment the specimen breaks, thus ensuring the exact strain applied being indicated. The strain is applied by means of a hand-wheel and gearing, and is indicated automatically on a dial. A graduated scale is attached for indicating the elasticity and elongation of the specimens, and special clips can be provided by means of which single threads can be tested. The larger sizes can, if desired, be made to drive by means of mill power in addition to the hand-wheel attachment.

Strength of Cotton Fibres. Mr. O'Neill some years ago made many experiments with a view to obtaining the strength of the different fibres, and the following table, compiled by him, will be of interest to the general reader; the figures indicate the mean breaking strain in grains.

Sea Islands	83·0	Pernambuco ..	140·2
Queensland ..	147·6	New Orleans ..	147·7
Egyptian	12·72	Upland	104·5
Maranham	107·1	Surat (Dhollerah)	141·9
Benguela	100·6	Surat (Comptah)	163·7

Testing Cloth and Canvas. The British Admiralty test the cloth and canvas supplied to them by the machine shown in **105**, made by W. H. Bailey & Co., Ltd., of Manchester. It will take any size piece up to 24 in. in length and 6⅝ in. in width. To ensure accurate results the machine is tested by dead weights before the dial is graduated. This machine works up to a maximum pull of 600 lb., but a slight increase in dimensions would enable it to be used for testing leather belting.

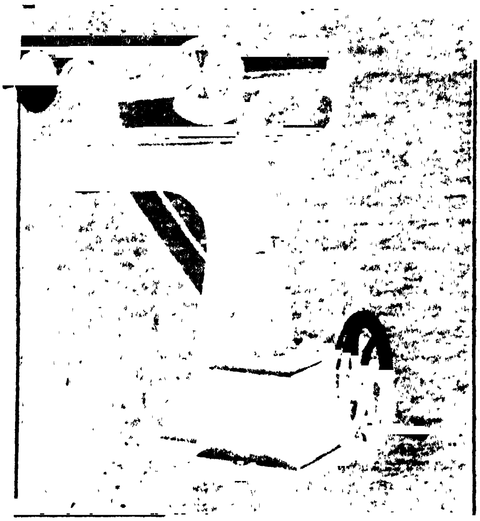
Leather Belts. The thickness of leather belts varies from $\frac{3}{16}$ to ¼ in., and the ultimate strength of the leather is about 3,086 lb. per square inch. The strength of leather belting per inch of width is as follows:

	Breaking Strain.	Safe working Strain.
Through solid part ..	675 lb.	225 lb.
Through riveting ..	382 lb.	127 lb.
Through lacing ..	210 lb.	70 lb.

and as the lacing is the weakest part, the strength of a laced belt must be measured by it. Roughly, it may be stated that a leather belt will transmit 1 h.p. per inch of width.

102. MACHINE FOR TESTING CHAINS

Strength of Glass. In some experiments on the transverse strength of glass carried out by the writer, the safe load in cwts. distributed, allowing a factor of safety of 4, was found to be $\frac{\cdot 75\, b\, d^2}{L}$, where b = breadth in inches, d = depth or thickness in inches, L = span in feet. Thick glass is often used in floors, to give light below. It is then sunk flush in a frame, so that the thickness becomes depth, the shortest width becomes span, and the breadth may be taken the full length of the sheet. For example, if it be required to find the thickness necessary for a sheet of glass 15 in. wide and 3 ft. long, to carry a safe load of 1¼ cwt. per foot super, we have 1·5 × 1·25 × 3 = 5·625 cwt. total load = W. Then the span must be taken the short way of the glass, or 1·25 ft. = L, and the breadth (b) will be taken the full length of the sheet = 36 in., and the equation stands as $5\cdot625 = \frac{\cdot75 \times 36 \times t^2}{1\cdot25}$ whence $t^2 = \frac{5\cdot625 \times 1\cdot25}{\cdot75 \times 36}$, or $t = \sqrt{\cdot26}$ = say, ·5 or ½ in.



103. WIRE-TESTING MACHINE

In a warehouse where heavy cases may be moved about, the corner of a case may be dropped upon the centre of a sheet, and a very large margin of strength must be provided for such a contingency. Probably double the above thickness would not be too much to meet such a case. For practical use this may be reduced to a very simple formula as follows. For a safe load of 1 cwt. per foot super make thickness in inches one-third of narrowest width in feet; for 1½ cwt. a thickness of four-tenths; and for 2 cwt. a thickness of one-half; and for a warehouse to allow for heavy loads and rough usage, the thickness in inches may equal the width in feet.

STRENGTH OF GLASS.

Variety.	Ultimate strength lbs. per square inch.		Specific gravity.
	Tension.	Compression.	
Flint glass ..	2,400	27,500	3·08
Crown glass	2,540	31,000	2·52
Plate glass ..			2·76
Common green glass ..	2,806	31,800	2·53

WEIGHT OF GLASS.

Green glass	.. ..	165·13 lb. per cub. ft.
Bottle glass	.. ..	170·81 .. ..
White glass	.. ..	180·75 .. ..
Flint glass	.. ..	208·06 .. ..

Testing Indiarubber. Indiarubber, for mechanical uses, should not give the slightest sign of superficial cracks on being bent to an angle of 180° after five hours' exposure in a closed air-bath to a temperature of 257° F. The test pieces should be about 2¼ in. thick.

Rubber containing not more than 50 per cent. by weight of metallic oxides should stretch to five times its length without breaking.

Pure caoutchouc, free from all foreign matter except the sulphur necessary for its vulcanisation, should stretch seven times its length without breaking.

The extension measured immediately after rupture should not exceed 12 per cent. of the original length of the test-piece. The test-pieces should be from ⅛ in. to ½ in. wide, and not more than ¼ in. thick and 1¼ in. long..

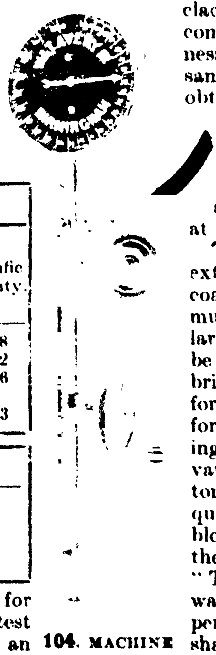
The percentage of ash gives a certain indication of the degree of softness, and may form a basis for the choice between different qualities for certain purposes. (Vladimiroff.)

Suggested Practical Tests. Three test-pieces shall be cut, each 2 in. × 2 in. × 1 in.

1. This piece shall float in fresh water, and be retained for future reference with the date and name of maker written upon it in ink.

2. This piece shall be screwed up between two plates to a thickness of ⅜ in. and left in a temperature between 50° and 70° F. for 24 hours; the permanent set or loss of thickness one hour after release shall not exceed 12½ per cent. = ⅛ in.

3. This piece shall suffer 10,000 machine blows at the rate of 120 per min., each compressing it to ¾ in. thickness, with a permanent set not exceeding 12½ per cent., and without cracking at the edges.



104. MACHINE FOR TESTING YARN AND FIBRES

Indiarubber washers are used to form a closing spring on the spindles of mushroom clack valves. By experiment they compress one-third of their thickness in ordinary work, and the same amount of compression is obtained by a direct load of 1¼ cwt. per square inch on the indiarubber.

Gutta-percha used for rings in the joints of hydraulic pressure pipes should become plastic at 150° F.

Testing Pitch. Owing to the extensive removal of the oils from coal-tar pitch, it is very frequently much too brittle, and requires a larger proportion of creosote oil to be mixed with it than formerly to bring it to the proper consistency for use. When used as grouting for granite pitchers for road paving, the addition of creosote oil varies from 25 to 65 gallons per ton of pitch, according to its quality, and rather more for wood block paving. A test of pitch of the proper quality is as follows "The pitch, when immersed in water for five minutes at a temperature of 60° C. (140° F.), shall twist without breaking, and melt at 100° to 115° C. (212° to 239° F.). It must remain hard at the normal temperature, and be capable of carriage in bulk. Its fracture must be dead black, and not greasy to the touch; it must be free from water, earth, and other substances not found in the distillation of tar." (Holt.)

Strength of Bolts. For structural work, bolts may be strained to 3 tons per square inch of minimum section, but bolts in machinery subject to varying loads should not be strained to more than 2 tons per square inch of minimum section. A bolt 1 in. diameter, being ·84 in. diameter or ·55 sq. in. area at bottom of thread, will take no more than (say) 2,000 lb., including initial strain in screwing up.

Let d = outside diameter of thread in inches; 2,000 d^2 = safe load in lb. for 1 in. bolts and upwards; 2,000 d^3 = safe load in lb. for 1 in. bolts and under.

The ordinary force used in screwing up bolts is liable to break a ⅜ in. bolt and seriously injure a ½ in. bolt; hence bolts for joints requiring to be tightly screwed up should not be less than ¾ in. in diameter.

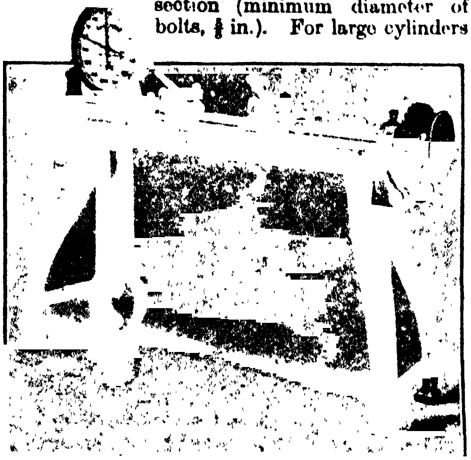
The approximate area of Whitworth bolts at bottom of thread = diameter of bolt in eighths of an inch × (diameter in eighths of an inch − 1) ÷ 100.

Whitworth Standard Bolts and Nuts. The Whitworth standard thread is a V-thread with an angle of 55 degrees, the depth equal to 64 per cent. of the pitch and one-sixth of the depth rounded off at top and bottom. It is now universally used by English engineers, whereas formerly each manufacturer created his own standard, so that the nuts made by one would not fit the bolts made by another. The thickness of the nut is made equal to the diameter of the bolt and the thickness of the head is made three-fourths of the diameter. The adjoining table gives the proportions, and a standard engineers' bolt is shown in **108**.

Bolts for Steam Cylinders. When bolts and nuts are used in connection with steam machinery it is necessary to use more caution. The following are the usual rules (Unwin).

	Per sq. in. net area.
(*a*) Bolts not requiring to be tightened before load is applied, also (*c*) when cylinder exceeds 60 in. diameter.	Safe load = 6,000 lb.
(*b*) Bolts accurately fitted and requiring to be tightened moderately, also (*c*) when cylinder exceeds 20 in. diameter	Safe load = 4,000 lb.
(*c*) Bolts used to draw joints steam-tight and resist the pressure in addition	Safe load = 2,000 lb.

For flange studs the rules are: for small cylinders allow 2,700 lb. per square inch of net section (minimum diameter of bolts, ⅝ in.). For large cylinders (over 18 in. diameter) allow 3,000 lb. per square inch of net section.



105. MACHINE FOR TESTING CLOTH AND CANVAS

Carpenters' Bolts. The standardisation of bolts has not yet quite reached to those for carpenters' use, but there is every reason why it should be effected. Much ignorance of the functions and strength of bolts is often displayed in heavy timber work, where it is essential that good judgment should be shown.

The proportions adopted by the writer for many years and found to work well in practice are given on the next page.

WHITWORTH STANDARD BOLTS AND NUTS.

Diam. of bolt in inches.	Threads per inch.	Diam. at bottom of thread.	Area at bottom of thread.	Thickness of head.	Diam. over flats.	Diam. over angles.	Diam. of tapping hole.
½	12	·3932	·1215	·4375	·9191	1·0612	$\frac{13}{32}$
⅝	11	·5085	·2030	·5468	1·1010	1·2713	$\frac{1}{2}+\frac{1}{32}$
¾	10	·6219	·3037	·6562	1·3012	1·5024	$\frac{5}{8}+\frac{1}{32}$
⅞	9	·7327	·4216	·7658	1·4788	1·7075	$\frac{3}{4}$
1	8	·8399	·5540	·8750	1·6701	1·9201	$\frac{7}{8}$
1⅛	7	·9420	·6969	·9483	1·8605	2·1483	$\frac{15}{16}+\frac{1}{64}$
1¼	7	1·0670	·8941	1·0937	2·0483	2·3651	$1\frac{5}{64}$
1½	6	1·2865	1·2998	1·3125	2·4134	2·7867	$1\frac{5}{16}$
1¾	5	1·4938	1·7525	1·5312	2·7578	3·1844	$1\frac{1}{2}+\frac{1}{32}$
2	4½	1·7154	2·3110	1·7500	3·1491	3·6362	$1\frac{3}{4}$
2½	4	2·1798	3·7300	2·1875	3·8490	4·5000	$2\frac{3}{16}$
3	3½	2·6340	5·4510	2·6250	4·5310	5·2320	$2\frac{5}{8}$

PROPORTIONS OF BOLTS, NUTS AND WASHERS IN CARPENTRY.

Thickness of nut	1	diameter of bolt.
Thickness of head	¾	..
Diameter of head or nut over sides	1¾	..
Side of square washer for fir	3½	..
Side of square washer for oak	2½	..
Thickness of washer ..	¼	..

When the nuts are let in flush in fir, the washers should be the same size as for oak.

The greatest working load on bolts in tension may be taken as 1-in. bolt for 1½ tons, 1¼-in. bolt for 2½ tons, 1½ in. bolt for 3½ tons.

A carpenter's bolt with nut and washers of the above proportions is shown in **107**.

Strength of Springs. The strength of flat or slightly curved carriage or railway springs in several plates or leaves is given by the formula $d = 1{\cdot}64 \times \frac{s^3}{b(nt^3)}$, where d = deflection in sixteenths of an inch per ton of load, s = span in inches, b = breadth in inches, t = thickness of leaves in sixteenths of an inch, n = number of leaves.

The strength of spiral springs is given by the formula $W = \frac{ned^4c}{D^3}$, where W = weight to be applied in lb., n = effective number of coils, generally two less than apparent number in springs for compression, owing to the flattening of the ends to form a base, e = compression or extension of one coil in inches, according to requirements, d = diameter, or side of square of steel composing spring, in sixteenths of an inch, c = constant found by experiment, which may be taken as 22 for round steel and 20 for square steel, D = mean diameter of coil, say, eight times diameter of steel.

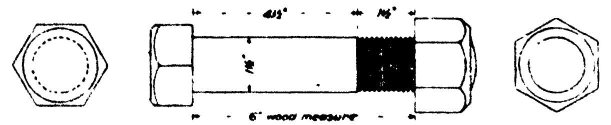
Strength of Pipes. A common rule for the strength of cast-iron pipes for water mains is $t = \frac{1}{4}\sqrt{d}$, where t = thickness and d = internal diameter, both in inches. The writer's rule for hydraulic pressure pipes working up to 750 or 1,000 lb. per square inch is $t = \frac{dp}{6000} + \frac{\sqrt{p}}{100} + \frac{\sqrt{d}}{10}$, where t = thickness, d = internal diameter, both in inches, p = working pressure in lb. per square inch. If to be used for steam-pipes, the same formula holds good with the addition of ⅛ in. to the thickness. Lord Armstrong's rule for pipes in connection with his hydraulic machinery was $t = \frac{1}{8}d + 25$.

Strength of Hydraulic Cylinders. The common rule is thickness of cast-iron cylinder equal to radius of bore, and this is supposed to be safe with an internal pressure of 3 tons per square inch, but it is really not safe at more than 2 tons per square inch with ordinary metal.

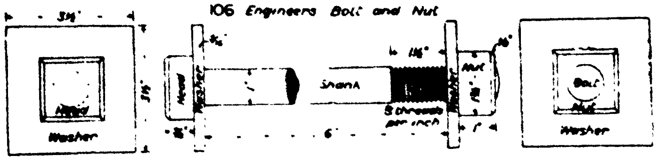
Continued

SPECIFIC GRAVITY AND WEIGHT OF COMMON SUBSTANCES NOT PREVIOUSLY GIVEN.

Name.	Specific Gravity.	Weight lb. per cubic foot.
Amber	1·09	67
Ashes	—	37
Asphalte	2·5	156
Beeswax	·96	58 to 62
Bitumen	1·06	62
Books	—	40
Camphor	·99	62
Charcoal, animal .	·80	—
,, from birch	—	34
,, ,, fir	—	28
,, ,, oak	—	21
,, ,, pine	—	18
Clay	1·9	120 to 135
,, potters'	—	120
Coal, anthracite ..	1·53	95
,, Newcastle ..	1·27	79
Coke	·744	46 to 47
,, solid	—	60
Earth	1·52 to 2·0	70 to 126
Emery	—	250
Flint	2·59	162
Gravel, coarse ..	—	120
,, fine	—	112
Gutta percha .. .	·96 to ·999	60 to 61
Gypsum	2·20	140 to 143
Ice	·92	58
Indiarubber	·915 to ·93	58 to 62
Ivory	1·82 to 1·91	114 to 120
Marl..	—	120
Masonry, flint ..	—	148
,, rubble ..	—	140
Mica	—	178
Peat, dry	—	55
Pitch	1·09 to 1·15	69 to 72
Plaster of Paris ..	1·29	80
Plumbago . ..	2·68	140
Pozzolana	—	170
Pumice stone ..	—	57
Resin	1·2	—
Sand, pit (fine) ..	—	95
,, ,, (coarse)	—	100
,, quartz ..	2·65 to 2·75	166 to 171
,, river	1·88	117 to 118
,, Thames ..	1·64	102
Shingle	1·42	88 to 95
Snow	—	5 to 12
Straw, thatch ..	—	3·5
Tallow	·92 to ·94	59
Tar	1·02	63
Terra-cotta	—	122
Tile, common ..	1·81 to 1·85	112 to 115



106 *Engineers Bolt and Nut*



107 *Carpenters Bolt Nut and Washers*

Continued from page 1589

ARE WE WHAT WE MAKE OURSELVES?

Our Powers of Acquiring Mental Qualities. Racial Differences and Influence of Religion and Training. Can We Exterminate Vice?

By Dr. GERALD LEIGHTON

THERE are two sets of acquirements open to man to "make"—physical and mental acquirements. So, in the same way, men are born with two sets of innate traits—physical and mental. Yet how few of us recognise the immense difference there is in the range of possibilities in the two spheres.

Physical and Mental Acquirements. The extent of man's physical acquirements is extremely limited, and very definite. The direction and the extent of growth in any structure of the body is limited by the inborn tendency of the species. Thus, no man can acquire by the stimulus of food and exercise more than a given strength, which can be stated in figures for the average of the race. But in the mental sphere it is very different. Compared with the body, the mind has extreme ductility. It has an immensely greater power of making acquirements. The amount of development which can be got physically by exercising and using the hand is strictly limited. But a man may *learn to use* his hand in a thousand ways, and these are mental, not physical, acquirements. "The artist's skill in guiding his hand is as naught compared to the rest of his mental achievements—as naught to the rest is the skilful penmanship of the historian, the poet, or the philosopher. Who, in estimating the greatness of the architect or the engineer even thinks of the skill with which he moves the pencil or the ruler? Who can even name a manual dexterity which underlies the success of the statesman or the general? The real adaptability, the real plasticity of man, therefore, lies in his mind, not in his body," says Dr. Reid. It is not physically that man is superior to the other animals; in many faculties he is immensely inferior.

The Real Intellectual Giants. In his power of making mental acquirements, however, he stands pre-eminent, and it is the evolution of this power of acquisition that has resulted in the evolution of man. Physically, to a much greater extent than mentally, man is the result of a long past selection. Mentally, to a much greater extent than physically, man is the result of his immediate surroundings, in virtue of his great power of mental acquisition. This power is greatest in the young, and it is astonishing with what rapidity the mind of a child makes acquirements. Dr. Reid truly states that the real intellectual giants are little children. "Oh, for the mind of a little child," may well be the prayer of the serious student of science or religion, because in later life we lose the capacity of making acquirements. The chief difference between the child and the adult is here, and, since the surroundings of individuals and their opportunities are so varied, therefore we see the great differences in character and mind in adult individuals. Physically, man is to a great extent what heredity makes him. Mentally, he is to a great extent what he makes himself, limited, it is true, by the inborn capacity for learning, but with an immensely wider range of mental acquirements open to him than he has for physical improvement

The Growth of the Mind. Hence, no two men *know* exactly the same things or the same amount. Take two identical twins, who are extremely alike physically. Their inborn physical and mental traits are extremely similar. Separate them in infancy, and place them in totally different surroundings. As adults they would be physically still much alike. Mentally they would have nothing in common. Hence it is, of course, that children show what seem to us such startling mental variations from their parents. They make different acquirements, and these are so prominent that they overshadow the inborn resemblances. It is hard in any given case to distinguish what is acquired from what is inborn, but the sum total is that man, especially mentally, is "a bundle of capacities for making acquirements, actual acquirements, and instincts which are mainly incitements to make acquirements." If the child's capacity for making these could only be continued in the adult, it would alter the complexion of the world "There would be only one religion, the true one, whatever that may be. Intellectual stagnation would fade, progress would be fast, there would be no poverty and no crime. But the growth of the mind is parallel to its organ the brain, rapid at first, then slow, then regressive in old age." (Reid.) So it is that it is only by slow degrees that we make advances. But since it is this power of making mental acquirements which causes individuals, and therefore nations, to differ chiefly, it becomes of great interest and importance to note in what manner the evolution of man has come about so as to produce the races and nations of to-day, in all their diversity of custom, thought, religion, and intellectual endowment.

Differences and Changes in Races. We may, for the moment, defer what we have to say concerning the physical differences in the races of mankind until we deal with Anthropology. We wish to note here that the mental differences which are observed in races and nations are mainly acquired, and not inborn. The actual inborn instincts are slight, and the inborn racial characters cannot be many, for the very simple reason that they are subject to such extremely rapid alteration. The study of comparative religions proves this admirably, and illustrates the effect of religious systems of teaching upon the power of making mental acquirements. The progress of nations is one of the improvement of external advantages, so that the natural capacity for making acquirements is given its opportunity. It is only, in these capacities for gaining and using the acquirements of the mind that races differ to any great extent. It must be remembered that acquired characters are liable to be changed for a whole race in a very short time, as is seen in such cases as the Japanese and the Maories, the latter of whom in a single generation have become civilised from savage.

The Influence of Religion. Systems of religion and systems of teaching are of the most vital importance in directing and giving opportunity for advance in mental capacity. Curiously enough, almost all religions have tended to restrain the instinct of curiosity, which is the main stimulus to intellectual acquirements. The evolution of civilisation is always parallel to that of the religion associated with it, because of the effect the religion has upon the possibility of mental development. The latter is just what the religion of the race permits, and if a race has several religions it will also exhibit several degrees of civilisation corresponding to them.

It is the method of teaching that is all-important, not so much what is taught. It is because the adherents of every religion have at one period or another upheld some untrue beliefs that the world has seen such conflicts between religion and science. So far as a mind is taught to hold beliefs in an unthinking, unreasoning way, so far is that mind prevented from developing its capacity for acquiring knowledge. It makes no difference whether the belief is true or false, the effect upon the mind is the same. Whereas, if the mind be trained to discriminate, if reasons are given before deductions are drawn, then it makes but little difference whether the deduction be true or false. If true, well and good. If false, the mind thus taught will sooner or later so develop as to discover the falseness, and little harm is done. Knowledge without the power of drawing inferences is useless.

The Source of Racial Differences. It will be found on inquiry that most racial differences can be traced to these sources, the methods of teaching of religious systems. Religions taught in such a way as to prepare the minds for making still further acquisitions will be found along with progressive civilisations in which great men arise. Religions taught in such a way that they are held as superstitions, whether true or false matters not, will be associated with civilisations which will be mere instruments of human suppression. Few great men will arise in such communities, and if they did they would not be recognised by minds untrained to make acquirements.

Newton would have been ignored during the Dark Ages, Darwin would have been burnt. Unless the mind is not only free, but taught to make all the acquirements of which it is capable, the end is intellectual stagnation, the result of a mental immorality.

Training as a Factor in Evolution. Racial mental characters are much more the result of training than of inheritance, and since races are simply numbers of individuals who are trained, it is obvious that systems of training are most potent factors in the mental evolution of any given race. The inborn characteristics of a race are so disguised by the acquired characters that it is difficult to detect them at all as far as the mind is concerned. And what is true of religious teaching is true of scholastic teaching. We have laid stress upon the point here because it is so little realised that intellectual progress is a matter which can be attained in leaps and bounds by the adoption of scientific methods of teaching. The thing has been done in some races. It could be repeated again and again in any nation which would study the problem of how to evolve itself mentally.

Once more we come to a problem of which we hear much, and which is again a matter of evolution and heredity. After all that has been said as to the course of organic evolution we ought to have some clearer ideas upon the matter. Unfortunately, ignorance of the true factors of national physical evolution is still rampant, and even where knowledge is, there is apathy in its application. It is popularly believed that adverse conditions of the parents, such as ill-health, disease, intemperance, want, hardship, bad hygienic conditions, and so forth, are the causes of a degenerate and deteriorated offspring. We have shown that this is not the case, and that, if it were, all races under such adverse conditions would become more and more degenerate until they were eliminated.

Can the Race be Improved? Students of biology and heredity, however, believe that racial physical improvement is due to natural selection of the fittest to survive, which implies that adverse conditions eliminate the unfit. They maintain that the children of the slums are ill-developed, not because their parents were exposed to the slum conditions, but because the children themselves are exposed to them. They are not allowed by their environment to acquire the characters they otherwise would do. No race can be shown to have degenerated from disease to which it has been long exposed; on the contrary, it becomes more and more immune or resistant. The peculiar characters of the inhabitants of crowded districts are due to their acquirements, and are not inborn, and in order to improve the individual all that is necessary is to see that he has the opportunity of making the acquirements of which he is capable. But let no one be deceived into thinking that by such means the race will be improved as a whole. That can be done only by devoting attention to inborn germinal characters which are inherited. Science has shown the way, as Mr. Bateson says; so far, no one proposes to take it.

We may close this portion of our study of heredity and evolution with another passage from

Mr. Bateson, words which deserve to be carefully digested by those to whom the welfare of the race is an object of care. They are full of meaning for the philanthropist and social reformer, as well as for the scientific student of

Mr. Bateson, addressing the Zoological Section of the British Association at Cambridge, said: "We may truly say that even our present knowledge of heredity, limited as it is, will be found of extraordinary use. . . . Breeding is the greatest industry to which science has never yet been applied. This strange anomaly is over; and, so far at least as fixation, or purification of types is concerned, the breeder of plants and animals may henceforth guide his operations with a great measure of certainty."

Can We Exterminate Vice? "There are others, who look to the science of heredity with a loftier aspiration, who ask, Can any of this be used to help those who come after us to be better than we are—healthier, wiser, or more worthy? The answer depends upon the meaning of the question. On the one hand, it is certain that a competent breeder endowed with full powers, by the aid even of our present knowledge, could, in a few generations, breed out several of the morbid diatheses. As we have got rid of rabies and pleuro-pneumonia, so we could exterminate the simpler vices. . . . Similarly, a race may conceivably be bred true to some physical and intellectual characters considered good. The positive side of the problem is less hopeful, but the various species of mankind afford ample material. In this sense science already suggests the way. No one, however, proposes to take it; and so long as, in our actual laws of breeding, superstition remains the guide of nations, rising ever fresh and unhurt from the assaults of knowledge, there is nothing to hope or fear from these sciences."

Transmission Unalterable. "But if, as is usual, the philanthropist is seeking for some external application by which to ameliorate the course of descent, knowledge of heredity cannot help him. The answer to his question is no, almost without qualification. We have no experience of any means by which transmission may be made to deviate from its course, nor from the moment of fertilisation can teaching, or hygiene, or exhortation pick out the particles of evil in that zygote, or put in one particle of good. From seeds in the same pod may come sweet-peas climbing five feet high, while their own brothers lie prone upon the ground. The stick will not make the dwarf peas climb, though without it the tall can never rise. Education, sanitation, and the rest are but the giving or withholding of opportunity."

It is quite true that you cannot make a silk purse out of a sow's ear, but you can give the sow's ear the chance of doing the very best work of which a sow's ear is capable. That is all that education, social reform, indeed any environment, can accomplish for the individual. But, from a national standpoint, it is more than has ever been done yet.

And here, for the moment, we must leave the evolution of man to turn our attention to him as he is seen in the races of the world, and then in the psychological and psychical parts of his nature.

Continued

Group 25

PHYSIOLOGY

12

Continued from page 1606

BONES, JOINTS, AND MUSCLES

Number, Position, and Form of the Bones of the Limbs. How the Various Bones are Jointed. Structure of Voluntary and Involuntary Muscles

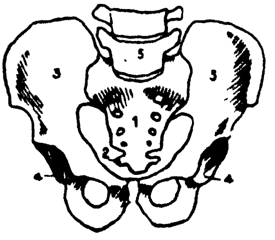
By Dr. A. T SCHOFIELD

The Arm. The Arm contains 30 bones, and is divided into three parts: The upper-arm, with one bone; the forearm, with two bones; and the hand and wrist, with 27.

The Humerus [90] (Latin *humerus*, shoulder) is the name of the arm-bone. It has a rounded head above, fitting into the socket in the shoulder-blade, which is so very shallow that the shoulder is easily put out of joint—ten times as frequently as any other bone in the body. It is so shallow in order to allow free movement of the arm in every direction. The lower end of the humerus is broad, and shaped like a door hinge.

The Ulna is so called because it forms the elbow, and is the inner bone of the forearm. It has a broad socket above, exactly fitting into the end of the humerus, and forms a strong hinge-joint; it is pointed below. The end of the ulna, which makes the tip of the elbow, locks into the humerus when it is extended and thus prevents the arm from folding backwards.

Bones of the Forearm. The Radius (Latin *radius*, a spoke) is the outer bone of the forearm. It is narrow above and broad below, where it joins the wrist and carries the hand. This bone moves above and below in two strong rings that join it to the ulna and enable it to turn round it. If you place one of your forearms and the back of the hand on a table, the radius is the outer bone and the ulna the inner. Now, without raising the arm or moving the elbow you can turn the hand right over, palm downwards, and you can see and feel the radius turning over the ulna, which has never moved at all. Remember the *radius turns, and forms the wrist joint; the ulna is fixed, and forms the elbow joint*. The elbow joint is twisted a little inwards, so that the forearm does not fold straight on to the arm, but centrally, towards the mouth, where it is much more useful, as we very seldom put our hand on the shoulder of the same side, but often use it to carry food to the mouth.



89. FRONT VIEW OF PELVIS

1. Sacrum of five vertebræ
2. Coccyx of four vertebræ
3. Innominate, or hip bone
4. Acetabulum, or socket for head of femur
5. Fifth lumbar vertebra

Bones of the Hand. The Hand may be divided into three parts: The *wrist*, which has eight bones; the *hand*, which has five bones; and the *fingers*, which have 14 bones. The bones of the wrist are short and square and are all so united by fibrous tissue that each can bend slightly, and they thus make flexible but very strong joints. They are called carpal bones (Latin *carpus*, a wrist).

The hand is formed of five bones, which can be felt along the back of a thin hand; they are called metacarpal (Greek *meta*, beyond; *carpus*, wrist).

The fourteen bones of the fingers are called phalanges (Greek *phalanx*, a rank), because they stand in rows, like so many soldiers; three form each finger, and two form the thumb.

The use of so many bones is not only to give every possible variety of movement, but to give great resistance to any blow or shock, as in falling on the hands.

Bones of the Legs. The Hips [89] are constructed of four bones which, joined together, make what is called the *pelvis*, or basin, because it is like a basin with the bottom out. The four bones are the *sacrum* and *coccyx*, forming the base of the spine behind, and the two *hip bones* (called *ossa innominata*, or nameless bones), one at each side, which meet in front. This basin holds and supports the lower organs of the body, and is broader and stronger in man than in any animal, in order to maintain his upright position.

The two very deep *cups* or *sockets* on the outer side of the hip bones are for the heads of the thigh-bones.

The Legs are divided into three parts, like the arms, and composed of exactly the same number of bones, only that, as the bone that corresponds to the tip of the elbow, and forms the front of the knee, is separate, we count one for the thigh, three for the leg instead of two, and 26 for the foot instead of 27, because there are only seven bones in the ankle and instep.

The Femur [90], or thigh-bone, is the longest and strongest bone in the body, and longer in proportion than that of any other animal. The head of this bone is very round, and fits firmly into the deep cup of the hip-bone, so that, while the leg cannot move so freely as the arm-bone, it is much less likely to be dislocated. The lower end of the bone is broad and flat to form the knee.

The Tibia (90) or flute-bone, is the large bone of the leg. Unlike the ulna in the arm, which only forms one joint, it not only forms the knee joint above, but the ankle joint below. You can trace it all along, just under the skin, where it is called the *shin*.

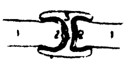
The Fibula (or buckle bone) is so called because the knee buckle used to be worn over it, on the outer side of the leg. It is a long, thin bone, fixed at the outer side of the tibia, and corresponds to the *radius* in the arm, but, unlike it, does not form the lower joint, but only protects the outer side of it. Neither can it turn round the other bone, for we do not require to turn our feet over, as we do our hands. The Patella, or knee cap, is a small bone that protects the front of the knee joint.

Bones of the Foot. The Foot has 26 bones, and may be divided into *ankle*, *foot*, and *toes*.

The Ankle (and instep) is formed of seven short, strong tarsal bones, much larger than the carpal bones of the hand ; one of them forms the heel, the others make up the beautiful arch of the foot called the instep. The foot is formed, like the hand, of five long bones, called metatarsal. The toes are called phalanges like the finger bones, and are also 14 in number.

We will now compare the arm with the leg [90], and you will see that though there is a general correspondence, there are radical differences, so that in no sense is the arm a sort of fore-leg. The bones are all smaller and shorter in the arm, the joints are much weaker and more flexible. The shoulder and hip joints are both formed on the same principle, and yet one is almost the weakest joint in the body and the other one of the strongest. The knee and elbow differ still more ; the former being entirely made for supporting weight on its broad, flat surface, the latter for the easy movement of a door on its hinges. The ankle and wrist are entirely different joints ; the wrist is made for limited but firm movements in all directions, the ankle for the foot to move, as the elbow does, up and down like a hinge. Then, as we have seen, the hand can be turned over backwards or forwards ; the foot, of course, cannot. The heel in the foot, formed of one of the strongest bones of the ankle, has no counterpart in the hand.

How the Bones are Jointed. We now turn to consider joints, which really are the hinges on which the bones move. The ends of the bones composing a joint are smooth, enlarged, and rounded so as to fit, more or less closely, into one another. The bone itself, near the joint, is all hard, compact tissue, and is covered with a smooth layer of cartilage. Bones are united by a fibrous capsule attached round each and lined with a fine membrane (called synovial membrane) which secretes a lubricating fluid (like the white of an egg) called synovia. The joints are often strengthened by various bands and ligaments.



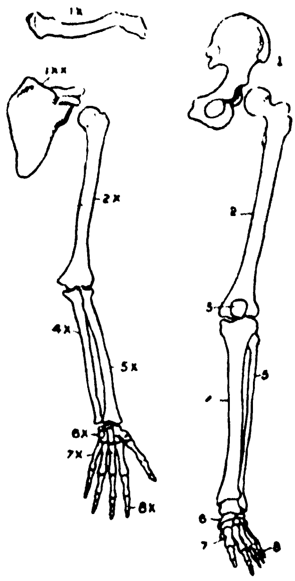
91. SECTION OF A MOVABLE JOINT
1. Bone
2. Cartilage
3. Synovial membrane filled with fluid

All the different bones of the body are connected by joints, or articulations of some sort.

These joints, or hinges, are of three varieties: Immovable, partly movable, and movable.

1. Immovable joints are formed by the joining of two bones together in such a way that they practically become one. The separate bones of the head and face are all thus united, except the lower jaw-bone, which is the only one that has a movable joint. The bones of the skull have edges like a saw, which lock into each other, leaving just a line where they were once divided. The teeth are also firmly fixed in the jaw, and cannot move till they fall out.

2. In partly movable joints, the bones do not absolutely unite, but are covered, where they join, with a little gristle, and are bound together by strong bands that fix them very firmly, but just allow the least possible movement on each other. It is in this way that the hip-bones are joined to form the pelvis, and the vertebræ to form the spine. The bones of the ankle and wrist are joined in the same manner.



90. BONES OF THE LEFT ARM AND LEG COMPARED
1x. Clavicle 1xx. Scapula 1. Side of pelvis 2x. Humerus 2. Femur 3. Patella 4x. Ulna 4. Tibia 5x. Radius 5. Fibula. 6x. Carpus 6. Tarsus 7x. Metacarpus 7. Metatarsus 8x. Phalanges 8. Phalanges

3. Movable joints [91]. Here the ends of the bones are expanded and made to fit each other, frequently in the shape of a cup and ball. They are constructed in the way we have already described.

These movable joints are of four distinct varieties, the ball-and-socket joint, the hinge joint, the gliding joint, and the pivot joint.

The *ball-and-socket joint* resembles a ball fixed in a cup so as to move freely any way. This is seen at the shoulder and hip [92].

In the *hinge joint* one surface is fitted into the other, so that the bone can only move backwards and forwards, like a door on its hinge. We find this at the elbow and knuckles of the fingers.

In the *gliding joint*, one bone slides on another freely, as at the ends of the collar-bone, in some of the wrist and ankle bones, and in the knee joint.

In the *pivot joint* a pivot works in a ring, like the hinge on some iron gates. It is found at the top of the radius, where the bone turns in a fibrous ring ; and in the atlas and axis, where the one forms the ring and the other the pivot, enabling the head to turn from side to side.

All the joints of the head, as we have seen, are fixed joints, except the lower jaw, which alone can move. This is both a sliding and hinge joint, and sometimes, if we yawn or gape too much, it slides out of its socket, and our mouth is fixed wide open, the jaw being said to be *dislocated*, or *out of joint*.

We have shown that *nodding is a sliding action between the head and the atlas, and that shaking the head is a ring-and-pivot motion between the atlas and axis.*

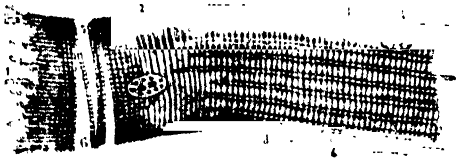
All the ribs are hinged on to the vertebræ so as to move up and down in breathing like the handle of a bucket.

92. HIP JOINT, SHOWING CUP AND BALL

Movements of the Arm and Foot. The arm being fixed at the shoulder in a loose ball-and-socket joint, is capable of circumduction, or movement round in *both directions*.

The elbow, being only a hinge joint, can, of course, only move two ways—backwards and forwards. The joint at the knuckles of the hand (not of the fingers) is a peculiar one [93], and is shaped like a saddle. You can spread your fingers and move them sideways, as well as move them backwards and forwards, just as in a saddle you can rock in your seat from side to side, as well as backwards and forwards. So that these joints are not ball-and-socket joints, and will not move all ways, like the shoulder; nor are they merely hinge joints, like the knuckles of the fingers, which only move backwards and forwards, but are a sort of double hinge, allowing a side movement as well.

The foot and toes are on the same pattern as the hand, but do not move nearly so freely. The joint of the big toe is often dislocated by ill-shaped boots, which press it too much outwards towards the other toes.



94. STRIPED MUSCULAR FIBRE AFTER TREATMENT WITH WEAK ACID

1. Muscular fibrillæ 2. Transverse striation 3. Longitudinal striation 4. Sarcolemma cells 5. Transverse cleavage 6. Sarcous elements

We have seen that the *pleura* between the lungs and ribs forms a sort of joint, since one surface of the closed bag glides on the other, and in the same way the *pericardium* round the heart and the *peritoneum* round the digestive organs also resemble joints; so that rheumatism, which always attacks the joints, often settles here, as well as in the limbs.

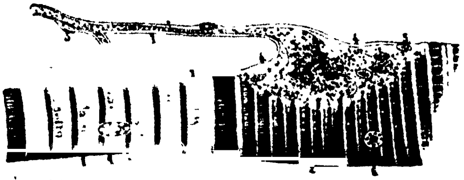
The hip is a very strong ball-and-socket joint, and the only things that prevent the thigh moving in all directions are the strong bands that are attached around it.

The knee, having only two flat surfaces, looks as if it could easily be put out of joint, but really it is a very strong joint, as the two bones not merely glide on each other, but are firmly united together by two very strong bands of fibre in the middle of the joint, passing from one bone to the other in the form of a cross, and hence called the crucial ligaments. This joint is also protected by strong muscles all round.

The ankle joint is a hinge joint of very strong construction.

Muscles and their Use. We have now to consider the muscles, that contractive tissue which is the agent of all movement. We will look at their varieties, structure, and chemical composition, and the functions they perform Muscles derive their name from *musculus* (Latin), a little mouse, because, being pointed at both ends and broad in the middle, they resemble one. All flesh is muscle, and all muscle is called flesh. The muscles are not *in* the flesh, *they are the flesh*. Each muscle is separate from the rest, and there are about five hundred of them in the body—250 pairs and five single muscles. They cover all the bones, and are covered themselves by the fat and skin, as can plainly be felt if you grasp the arm. The flesh, therefore, does not cover the bones in a solid layer, but is composed of many separate muscles. Each muscle is enclosed in a smooth, glistening sheath that separates it from the next, as you can sometimes clearly see in a leg of mutton. But although muscles cover, strengthen, and support the body, their principal use is to enable us to move. No movement can take place without a joint that can move, and a muscle to move it. Muscles are of all sizes. There are very strong ones in the arms, and still stronger ones in the legs. The longest muscle in the body is nearly 2 ft. long, and reaches from the hip to the inside of the leg below the knee; is called the sartorius, or *tailor's muscle*, because it draws the leg up

93. THIRD AND LITTLE FINGER OF LEFT HAND, SHOWING CONNECTING LIGAMENT



95. STRIPED MUSCULAR FIBRE, SHOWING NERVE ENDING

1. Striped muscle at rest 2. Striped muscle during contraction 3. Motor nerve 4. Nerve end plate 5. Nuclei in end plate 6. Sarcolemma cells

when sitting cross-legged like a tailor. The smallest muscle is only ¼ in. long, and is in the ear. There are about 150 muscles in the back alone to keep the spine erect, and these are of great importance. The muscles that form the front of the abdomen, where there are no ribs, are just as important, because they have to protect all the internal organs. The calf of the leg is composed of muscles, and is connected with the strongest tendon in the body, called the Achilles tendon, placed just at the back of the ankle, where it is fixed on to the heel. A muscle, like all other tissues, increases in size by use, while, if it is not used, it wastes away.

96. TRANSITION FROM STRIPED MUSCLE TO TENDON

Voluntary and Involuntary Muscles. Muscles constitute 45 per cent. of the weight of the body, and, besides forming a large part of the limbs, they are used internally to surround canals, organs and vessels, either to regulate their size or their movement, to close their orifices, or for other purposes. Muscles, broadly speaking, are of two varieties—the striped, or voluntary, and the unstriped, or involuntary. The former, under the control of the will as a whole, though not individually, are attached to all parts of the skeleton, move all the joints and bones, and are the organs of locomotion. They are connected with the animal life and the spending of force, and are set in action by voluntary nerve impulses. They act quickly, decidedly, and simultaneously in all their parts. They are capable of great exertion, but soon get tired. They are called striped because under the microscope narrow bands are seen running across them.

The unstriped, or smooth muscles, differ from these in almost every respect. They are concerned with the vegetative side of life, or the building up of force, and form a large part of all the internal organs and tubes; they are not under the conscious will, and derive their impulses from involuntary, or "sympathetic" nerves. They act in a slow, gradual manner, and never as a whole; but the motion spreads like a wave from fibre to fibre in a way that is called *vermicular*.

There is a third variety of muscle, found only in the heart, combining the characteristics of the other two. It is like the first in being striped, and in acting decisively and simultaneously, but resembles the second in being absolutely involuntary. The heart beats entirely without our will or knowledge, for by no effort can a man stop the beating of his own heart. This muscle is the busiest one in the whole body. It contracts the heart 70 times every minute, day and night, for perhaps 70 or 80 years.

98. THE MUSCLES

Structure of the Muscle. Turning now to the construction of a muscle, we see first of all by the naked eye that each muscle consists of separate bundles, all united together by the covering skin. The bundles are made up of smaller bundles, and these of smaller, and these again of separate fibres [94], which are the muscle cells; they are like very short hairs, though when joined together they make up a large muscle.

Muscular fibres are well supplied with blood by means of small blood-vessels, which give flesh or muscle its red appearance. The fibres themselves are composed of a row of what look like oblong black and white beads called *sarcous elements*, and a nerve runs to each muscular fibre from the brain, and is attached to it by a flat plate, something like that which conveys the electricity in galvanic belts [95].

97. BICEPS OF ARM
B. Belly
O. Origin

How a Muscle Contracts. The nerve-current is supposed to act like an electric shock on the sarcous elements that make up the muscle fibres, and thus makes each element as broad as it was long, so that the whole fibre gets at once shorter and wider. It is in this way that muscle moves, as we see more fully in the next section.

All these separate fibres are bound together by connective tissues, and all the connective tissue-sheaths join together at each end of the muscle to form the firm white fibrous band or tendon that unites it to the bones [96]. Sometimes, as in the great muscles in the neck of a horse, by which it can wrinkle up its skin and shake the flies off, the muscle is very thin, and spread out like a piece of cloth.

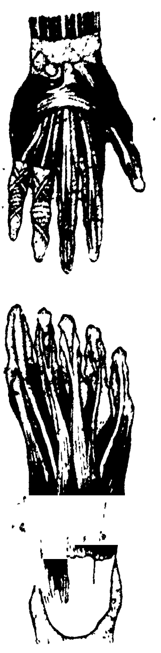
Muscle is soft and thick in the middle [97], and a band or tendon fastens it at each end to the bones it has to move.

The contraction may be imitated by tying a strong piece of elastic to the handles of a pair of scissors. The handles will represent two bones; where the scissors cross is the joint, and the elastic is the muscle that can draw the handles together if they are stretched apart.

Before a muscle acts, and while it is at rest, it is just like a *stretched band of tape*; but the moment the nerve current reaches it from the brain, the muscle suddenly becomes like a stretched band of indiarubber. All muscular movements are thus produced by the current the brain has the power to send along the nerve, for it can make the muscles like stretched bands of rubber. If you let your arm hang down, and catch hold of the middle of it with the other hand, and then bend the forearm up, you will feel the muscles getting thicker and harder under your hands; *so that a muscle causes motion by becoming shorter and thicker.*

Composition of Muscle. The general composition of muscle is as follows:

Water	75·0
Nitrogenous matter ..	20·0
Muscle sugars, or starch	1·0
Salts and ferments ..	4·0
	100·0



99. TENDONS AND MUSCLES OF HAND AND FOOT

Muscle is usually at rest, but as each fibre has a nerve running to it, the whole mass can be instantly contracted. The moment it is at work or contracted, it becomes acid. It uses more O and gives out more CO_2 to the blood, uses up the muscle sugar, produces nine units of heat for every unit of work, and gets broader and shorter. A muscle can contract three-fifths its entire length, and only takes one-twentieth of a second to do so; but it soon gets tired, contracts less vigorously, and at last ceases to move. Six hours or so after death it begins to coagulate and gets rigid—the state of *rigor mortis*, which lasts nine days.

Exercise Strengthens the Muscles. A muscle differs from all machines in becoming stronger the more work it does. We have so little occasion to move our ears that the little muscles have almost lost their power of contraction for want of use. Any part of the body not used wastes, and at last becomes useless. If the finger is placed in front of the ear when chewing, one can feel the muscle of the lower jaw contract; the muscles that pull it down can also be felt under the chin. At the back of the neck one may feel the two strong columns of muscle that keep the head erect upon the shoulders.

How the Limbs are Moved. The shoulders themselves are beautifully rounded by large, fleshy muscles that cover the bony surfaces, and end in strong tendons fixed in the upper part of the arms. It is these muscles that raise the arm and extend it level with the shoulder. Then we have strong chest-muscles fixed to the arm to draw it forwards, and strong muscles behind fixed to the shoulder-blade and arm to draw it backwards [98].

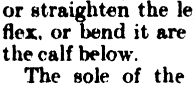
All along the arm are two sets of muscles. Those in front, including the biceps, are called *flexors*, because they bend the joints; those at the back are called *extensors*, because they extend the joints, so that one set pulls against the other. For instance, if you want to bend the arm with the biceps, the triceps behind prevents it doubling up too easily.

To the outer side of the elbow are fixed all the muscles that form the back of the forearm and extend the back of the hand and wrist. The fleshy part of the muscle is in the upper part of the forearm, while the wrist consists of all the tendons coming down from the muscles above to be fixed in the bones of the fingers they have to move [99]. If you work the finger about you can see the tendons moving under the skin at the back of the hand. The one that goes to the thumb can be seen very plainly if you extend the thumb far back. To the inner side of the elbow are fixed the muscles that form the front of the forearm, and flex the front of the wrist and hand. These also end in long tendons that run in grooves. The middle tendon can be very clearly seen if you touch the little finger with the thumb, and then bend the wrist forwards.

The muscles over the abdomen are very strong and broad, though quite thin. They can be greatly strengthened by exercise. The buttocks and thighs are all formed of enormous muscles, which move the leg in any direction. The long tailor's muscle, 2 ft. long, which is like a ribbon, and reaches from the hip-bone to below the knee, enables us to sit cross-legged like the Japanese. The muscles that extend or straighten the leg are all in front; those that flex, or bend it are all along the back, and form the calf below.

The sole of the foot [99] is formed of *four layers of muscles*, one below another.

Involuntary Muscles. So far, we have only spoken in detail of those muscles with which we are most familiar, all of which are striped, and under the control of the will. But we have alluded to another sort of muscle that moves our internal organs and carries on all the processes of life inside us. Such muscles have *no stripes*, they are not large, and are composed of altogether different cell-fibres [100]. They form part of the walls of the stomach and intestines, and of the blood-vessels, bladder, kidneys and other organs. They are not in any degree under the control of the will, but are governed by another nervous system altogether, the seat of which is not the brain, but behind the stomach. It is called the sympathetic system. From here fine red nerves stretch to all these *unstriped* and involuntary muscles, which are composed of small, spindle-shaped cells $\frac{1}{500}$ of an in. long, cemented together in masses. They are not striped or made in small beads like the striped muscle, but are composed of contractile substance. Their movements appear to be spontaneous. They do not get fatigued, and they work day and night unknown to us.



100. INVOLUNTARY, OR SMOOTH MUSCLES

1. A separate fibre
2. Layer of fibres

MISCELLANEOUS PROBLEMS

Clock Problems. Time and Work. Miscellaneous Problems. Duodecimals. Conversion of Ordinary into Duodecimal Measures

Group 21
MATHEMATICS
12

Continued from page 1530

By HERBERT J. ALLPORT, M.A.

CLOCK PROBLEMS

168. Consider the motion of the hands of a clock. In one hour's time the long hand goes completely round the dial—*i.e.*, passes over sixty minute-spaces, while the short hand only passes over five minute-spaces. Thus the long hand passes over 60 − 5, *i.e.*, 55 more spaces in an hour than the short hand does.

Example 1. At what time between 1 and 2 o'clock are the hands of a clock directly opposite one another ?

At 1 o'clock the long hand is 5 minutes *behind* the short hand. When the hands are opposite, the long hand will be 30 minutes *ahead* of the short hand.

Therefore, the long hand must gain 5 + 30 = 35 spaces on the short hand. But it gains 55 spaces in 60 minutes. Hence we have the proportion

55 : 35 :: 60 minutes : required time.

Therefore, Time

$$= \frac{60 \times \overset{7}{\cancel{35}}}{\underset{11}{\cancel{55}}} = \frac{420}{11} = 38\tfrac{2}{11} \text{ min. past 1 } \textit{Ans.}$$

Example 2. When will the hands be at right angles, between 4 and 5 o'clock ?

At 4 o'clock the long hand is 20 minutes behind the short hand. When the hands are at right angles, it must either be 15 minutes *behind* the short hand, or 15 minutes *ahead*. Therefore it must either gain 20 − 15 or 20 + 15 minutes, *i.e.*, 5 or 35 minutes. As in Example 1, we find that to gain 5 minutes, it takes

$$\frac{60 \times 5}{55} \text{ min.} = \frac{60}{11} = 5\tfrac{5}{11} \text{ min.}$$

And, since 7 × 5 = 35, it will take $7 \times 5\tfrac{5}{11}$ minutes, or $38\tfrac{2}{11}$ minutes to gain 35.

Thus, the required times are $5\tfrac{5}{11}$ minutes past 4 and $38\tfrac{2}{11}$ minutes past 4 *Ans.*

Other forms of clock questions, such as "at what time, between two stated hours, are the hands coincident," or "at what time are they any stated number of minutes apart," are worked in the same way.

169. Questions involving two clocks are generally simple applications of the principle of Art. **165.**

Example. Two clocks show the correct time at 9 a.m. on August 12. The one loses 8 seconds, and the other gains 12, in 24 hours. When will one clock be 5 minutes ahead of the other, and what time will each clock then show ?

At the end of 24 hours the clocks are 8 + 12 = 20 seconds apart. Therefore, they will be 5 minutes, or 300 seconds apart after $\frac{300}{20} \times 24$ hours, *i.e.*, 15 days.

Thus, one is 5 minutes ahead of the other at 9 a.m. on August 27. Also, in 15 days the first clock loses 15 × 8 seconds = 120 seconds = 2 minutes, so that at 9 a.m. on August 27 this clock points to 8.58. The other clock is 5 minutes ahead of this—*i.e.*, at 9.3.

TIME AND WORK

170. The fundamental principle here is

Work done per day × Number of days = Total to be done.

Example 1. A can do a piece of work in 6 days which B could do in 8 days. How long will they take over it if they both work together ?

Find the amount done per day, thus:

A does the whole piece in 6 days.

Therefore, A does $\frac{1}{6}$ of the piece in 1 day.

Similarly, B does $\frac{1}{8}$ of the piece in 1 day.

Therefore, working together, they do $\frac{1}{6} + \frac{1}{8}$ of the piece in 1 day $= \frac{4+3}{24} = \frac{7}{24}$ of the piece in 1 day.

Hence, they do $\frac{1}{24}$ in $\frac{1}{7}$ of a day, and therefore $\frac{24}{24}$, or the whole piece, in $\frac{24}{7}$ days, *i.e.*, $3\frac{3}{7}$ days *Ans.*

Example 2. A bath which holds 21 gallons can be filled by the cold water tap in 6 minutes, and by the hot water tap in 7. The waste-pipe can empty it in 3 minutes. If the bath is filled, and then all three pipes are opened, how much water will be left in the bath at the end of half an hour ?

The waste-pipe empties the bath in 3 minutes.

Therefore, it empties $\frac{1}{3}$ of it in 1 minute.

Similarly, the cold-water tap fills $\frac{1}{6}$ in 1 minute, and the hot-water tap fills $\frac{1}{7}$ in 1 minute.

Therefore, when all three are open $\frac{1}{3} - \frac{1}{6} - \frac{1}{7}$ is emptied in 1 minute, *i.e.*, $\frac{14-7-6}{42} = \frac{1}{42}$ is emptied in 1 minute.

Hence, after half an hour, $30 \times \frac{1}{42}$ or $\frac{5}{7}$ of the bath is emptied.

Therefore, there remains in the bath $(1 - \frac{5}{7})$ of 21 gallons $= \frac{2}{7}$ of 21 = 6 gallons *Ans.*

Example 3. A and B agree to do a piece of work for 30s. A could do the work alone in 5 days, and B could do it alone in 6 days. But, with the help of C, they finish the work in 2 days. How should the money be divided ?

A can do $\frac{1}{5}$ of the work in 1 day, so that in the 2 days which they work he does $\frac{2}{5}$.

Similarly, B does $\frac{2}{6}$, or $\frac{1}{3}$ of the work.

Hence, C does the remainder—*viz.*, $1 - \frac{2}{5} - \frac{1}{3}$ of the work $= \frac{4}{15}$ of the work.

Therefore,

$$\left.\begin{array}{l}\text{A should have } \frac{2}{5} \text{ of 30s.} = \text{12s.}\\ \text{B should have } \frac{1}{3} \text{ of 30s.} = \text{10s.}\\ \text{C should have the remaining 8s.}\end{array}\right\} \textit{Ans.}$$

EXAMPLES 20

1. A starts 3 minutes after B for a place 4½ miles distant. B, on reaching his destination, immediately returns, and, after walking a mile, meets A. If A's rate is 1 mile in 18 minutes, how many miles an hour does B walk ?

2. A train passed a station 40 miles away 2 minutes late. If it had travelled at 50 miles an hour, it would have been 10 minutes late. Find the rate of the train.

3. A man rows ¾ mile up-stream in half an hour. If there had been no current he would only have taken a quarter of an hour. How long will he take to row back again ?

4. A man drives to a certain town at 8 miles an hour. He returns by a road 2 miles longer, at 10 miles an hour. The return journey takes 12 minutes less than the outward journey. How long is each road ?

5. A person standing on a railway platform, which was 88 yards long, noticed that a train took 9 seconds in passing him, and took 21 seconds in passing through the station. How long was the train, and at what rate was it travelling ?

6. A man travelling 9 miles per hour is followed, 4 minutes later, by a man travelling 10 miles an hour. When and where will the second man overtake the first ?

7. A walks from one town to another at 4 miles an hour. At the halfway, he is overtaken by B, who walks 5 miles an hour. A now quickens to B's rate and finds that he arrives at his destination 15 minutes earlier in consequence. How far is it between the two towns ?

8. There are two candles, P and Q, one of them 1 inch longer than the other. P is lighted at 4.30, and Q at 6 o'clock. At 8.30 they are both the same length. P burns out at 10.30 and Q at 10. What were the original lengths ?

9. A and B do a piece of work in a certain time. If each had done half the work, A would have had to work one day less, and B two days more, than they actually did work. How long did they take, when they worked together ?

10. At noon on Monday a clock is 2 minutes fast, and at 8 a.m. on the following Wednesday it is 1 minute slow. When was it right ?

11. At what time between 5 o'clock and 5.30 are the hands of a watch 14 minutes apart ?

12. I row against a stream flowing 1½ miles per hour to a certain point, and then turn back, stopping 2 miles short of my original starting-place. If the whole time occupied is 2 hr. 10 min., and in still water I row 4½ miles per hour, how far up-stream did I go ?

13. A hare is 60 of her own leaps in front of a greyhound, and takes 3 leaps while the hound takes 2. But the hound goes as far in 3 leaps as the hare does in 7. In how many leaps will he catch the hare ?

14. Two cyclists start to meet each other. One rode 2 miles an hour faster than the other, and they met in 1½ hours. If each had travelled 2 miles per hour faster than he did, they would have met in 1¼ hours. Find the distance between the starting-places.

MISCELLANEOUS EXAMPLES

171. The following are types of examples which occur frequently.

Example 1. In what proportion must tea at 1s. 6d. per lb. be mixed with tea at 2s. 4d. per lb. in order that the mixture may be worth 1s. 9d. per lb. ?

1 lb. of the cheaper tea is worth 3d. *less* than 1 lb. of the mixture.

1 lb. of the dearer tea is worth 7d. *more* than 1 lb. of the mixture.

Hence, 7 lb. of the cheaper tea must be mixed with 3 lb. of the dearer tea. For 7 lb. of the cheaper will be worth 7 × 3d. = 21d., *less* than 7 lb. of the mixture, and 3 lb. of the dearer will be worth 3 × 7d. = 21d. *more* than 3 lb. of the mixture ; so that, together, they have the same value as 10 lb. of the mixture.

The required proportion is therefore $\underline{7 : 3}$ *Ans.*

Example 2. A man distributed £1 16s. 10d. amongst 85 children ; each girl received 4d. and each boy 6d. How many girls were there ?

If each child received 4d., the man would spend 85 × 4d. = £1 8s. 4d. This is 8s. 6d. too little.

If each received 6d., he would spend 85 × 6d. = £2 2s. 6d., which is 5s. 8d. too much.

Hence,

No. of girls : No. of boys ∷ 5s. 8d : 8s. 6d.
∷ 68 : 102

Therefore, the number of girls

$$= \frac{68}{68+102} \text{ of } 85 = \frac{2}{5} \text{ of } 85 = \underline{34 \textit{ Ans.}}$$

A question of this sort, however, need not be treated as a "mixture" problem. For, after each child has received 4d., the man is left with 8s. 6d., which he uses to give an extra 2d. to each boy. Now, 8s. 6d. contains 51 twopences. Hence, there are 51 boys, and therefore 85 − 51, or 34 girls.

Example 3. A person has to buy a certain number of oranges for a certain sum of money. If he buys at the rate of 3 a penny, he spends 8d. too much, and at the rate of 4 a penny he spends 1s. too little. Find the sum of money

At the first rate an orange costs $\frac{1}{3}$d.

At the second rate an orange costs $\frac{1}{4}$d.

The difference = $\frac{1}{3} - \frac{1}{4} = \frac{1}{12}$d.

Hence, by paying $\frac{1}{12}$d. less for each orange, he reduces the total cost by 8d. + 1s., or 20d.

Therefore, the number of oranges = 20d ÷ $\frac{1}{12}$d. = 240.

Now 240 oranges at 4 a 1d. cost 60d., or 5s., and this is 1s. less than the sum he has to spend. Thus, the required sum is 6s. *Ans.*

We have the same principle in the following :

A man walks to the station at 4 miles an hour and arrives 5 minutes late. Had he walked at 5 miles an hour he would have been 4 minutes too early. How far is it to the station ?

The first rate is 1 mile in 15 minutes, and the second is 1 mile in 12 minutes. Thus, by taking

3 minutes less over each mile, he takes 9 minutes less for the whole distance. The distance is therefore 9 ÷ 3, or 3 miles.

Example 4. A mixture of 280 gallons of spirit and water contains 70 per cent of spirit. How much spirit must be added in order to raise the proportion to 84 per cent. ?

Amount of water in the mixture = 30 per cent. of 280 gallons = 84 gallons.

After more spirit has been added, this 84 gallons of water forms (100 − 84) or 16 per cent. of the mixture. Hence, the total amount of mixture will then be $\frac{100}{16}$ of 84 gallons; *i.e.*, 525 gallons.

Therefore, the amount of spirit to be added = 525 − 280 = 245 gallons *Ans.*

Example **5**. I look at my watch between 5 and 6 o'clock. On looking again between 6 and 7 o'clock I find that the hands have exactly changed places. What was the time when I first looked ?

In a question of this sort, the chief point is to find what distance the hands are apart. Once this distance is known, the rest of the problem is worked in the same way as already explained in Art. **168**.

We know that the long hand moves through 60 minute-spaces while the short hand moves through 5—*i.e.*, in any given interval, the long hand moves through 12 times the distance through which the short hand moves.

Now, in the above problem, the distance through which the short hand moves is equal to the distance between the hands. The long hand, therefore, moves through 12 times this distance. Hence, if the long hand had moved on into the position now occupied by the short hand, it would have moved through 12 + 1, or 13 times the distance between the hands. But the long hand has now moved from a certain position which it occupied between 5 and 6 o'clock into the same position between 6 and 7 o'clock, *i.e.*, through 60 minute-spaces.

Therefore, 60 minutes = 13 times the distance between the hands ; so that the distance between them is $\frac{1}{13}$ of 60 minutes, or $4\frac{8}{13}$ minutes.

We have now, by the method of Art. **168**, to find " at what time between 5 and 6 o'clock is the long hand $4\frac{8}{13}$ minutes ahead of the short hand ? "

At 5 o'clock the long hand is 25 minutes behind the other. It has therefore to gain $25 + 4\frac{8}{13}$, or $29\frac{8}{13}$ minutes

Hence,

$$55 : 29\tfrac{8}{13} :: 60 \text{ minutes} : \text{reqd. time}.$$

Therefore,

$$\text{Reqd. time} = \frac{\overset{12}{\cancel{60}} \times \overset{35}{\cancel{385}}}{13 \times \underset{5}{\cancel{55}}} = \frac{420}{13}$$

$$= \underline{32\tfrac{4}{13} \text{ minutes past 5 } \textit{Ans.}}$$

DUODECIMALS

172. In finding the area of a rectangle by the method of Art. 153, or the volume of a rectangular solid by that of Art. 158, it is necessary to express every dimension in terms of the same unit. We have to reduce every dimension to yards, or to feet, or to inches, before working the multiplication. This, however, need not be done if we adopt the method of *Duodecimals*.

The foot is the unit of the system. The unit is divided as follows.

A *linear prime* is one-twelfth of a foot.

A *superficial prime* is one-twelfth of a square foot.

A *cubic prime* is one-twelfth of a cubic foot.

A *second*, linear, superficial, or cubic, is one-twelfth of the corresponding prime.

A *third* is one-twelfth of a second, and so on.

A prime, whether linear, superficial, or cubic, is denoted by 1′. Similarly, a second is denoted by 1″, a third by 1‴.

173. It is clear from the definitions that

(i.) A linear prime = $\frac{1}{12}$ ft. = 1 in.
  A linear second = $\frac{1}{12}$ in.
(ii.) A superficial prime = $\frac{1}{12}$ sq. ft. = 12 sq. in.
  A superficial second = $\frac{1}{12}$ of 12 sq. in. = 1 sq. in.
  A superficial third = $\frac{1}{12}$ sq. in.
(iii.) A cubic prime = $\frac{1}{12}$ cubic ft. = 144 cubic in.
  A cubic second = $\frac{1}{12}$ of 144 cubic in. = 12 cubic in.
  A cubic third = $\frac{1}{12}$ of 12 cubic in. = 1 cubic in.

We can thus convert duodecimal measures into ordinary measures. For example,

5 ft. 3′ 7″ = 5 ft. $3\frac{7}{12}$′ = 5 ft. $3\frac{7}{12}$ in.

7 sq. ft. 5′ 9″ = 7 sq. ft. (60 + 9) sq. in. = 7 sq. ft. 69 sq. in.

4 cubic ft. 3′ 8″ 5‴ = 4 cubic ft (432 + 96 + 5) cubic in. = 4 cubic ft. 533 cubic in.

Similarly, we can convert ordinary measure into duodecimals.

4 yd. 1 ft. 3¼ in. = 13 ft. $3\frac{3}{12}$ in. = 13 ft. 3′ 3″.

2 sq. yd. 5 sq. ft. 98 sq. in.

$$= 23 \text{ sq. ft.} + \frac{96 + 2}{144} \text{ sq. ft.}$$

$$= 23 \text{ sq. ft.} + \frac{8}{12} \text{ sq. ft.} + \frac{2}{144} \text{ sq. ft.}$$

= 23 sq. ft. 8′ 2″

3 cu. ft. 123½ cu. in

$$= 3 \text{ cu. ft.} + \frac{120}{1728} \text{ cu. ft.} + \frac{3\frac{6}{12}}{1728} \text{ cu. ft.}$$

$$= 3 \text{ cu. ft.} + \frac{10}{12^2} \text{ cu. ft.} + \frac{3}{12^3} \text{ cu. ft.} + \frac{6}{12^4} \text{ cu. ft.}$$

= 3 cu. ft. 10″ 3‴ 6⁗

174. We must now consider the multiplication of duodecimals.

$$1 \text{ ft.} \times 1' = 1 \text{ ft.} \times \frac{1}{12} \text{ ft.} = \frac{1}{12} \text{ sq. ft.} = 1$$ superficial prime.

$$1 \text{ ft.} \times 1'' = 1 \text{ ft.} \times \frac{1}{12^2} \text{ ft.} = \frac{1}{12^2} \text{ sq. ft.} = 1$$ superficial second.

Similarly, 1 ft. × 1‴ = 1 superficial third ; and so on.

Again,

$1' \times 1' = \frac{1}{12}$ ft. $\times \frac{1}{12}$ ft. $= \frac{1}{12^2}$ sq. ft. = 1 superficial second.

$1' \times 1'' = \frac{1}{12}$ ft. $\times \frac{1}{12^2}$ ft. $= \frac{1}{12^3}$ sq. ft = 1 superficial third.

Example 1. Find the area of a rectangle which measures 5 ft. 9 in. by 3 ft. 3 in.

5 ft. 9′
3 ft. 3′
17 3′
1 5′ 3″
18 sq. ft. 8′ 3″
= 18 sq. ft. + $(\frac{8}{12} + \frac{3}{144})$ sq. ft.
= 18 sq. ft. 99 sq. in. *Ans.*

EXPLANATION. Multiply 5 ft. 9′ by 3 ft. Thus,

3 ft. × 9′ = 27 super. primes = 2 sq. ft. 3′.

Put down 3′ and carry 2 sq. ft. 3 times 5, 15, and 2, 17.

Next, multiply by 3′.

3′ × 9′ = 27″ super. = 2′ 3″.

Put down 3″, carry 2′.

3′ × 5 ft. = 15′, and 2′ = 17′ = 1 sq. ft. 5′.

On adding the two lines, we get 18 sq. ft. 8′ 3″, which, by the last article, is equal to 18 sq. ft. 99 sq. in.

Example 2. The area of a rectangle is 100 sq. ft. 20 sq. in., and its length is 11 ft. 8 in. Find its breadth.

11 ft. 8′)100 sq. ft. 1′ 8″(8 ft. 7′ = 8 ft. 7 in. *Ans.*
93 sq. ft. 4′
6 sq. ft. 9′ 8″
6 sq. ft. 9′ 8″

EXPLANATION. 20 sq. in. is equal to 1′ 8″. Beginning the division, 11 ft. into 100 sq. ft. appears to go 9 times. But on multiplying 11 ft. 8′ by 9 we get 105 sq. ft., which is too big. Try 8. Then, 8 ft. × 8′ = 64′ = 5 sq. ft. 4′. Put down 4′, carry 5 sq. ft. ; 8 ft. × 11 ft. = 88 sq. ft., and the 5 carried make 93. Subtract, saying, 4′ and 9′ make 1 ft. 1′. Put down 9′ and carry 1 ft., etc.

Next 11 ft. into 6 sq. ft. 9′, or 81′, goes 7′. Multiply the divisor by 7′. Thus, 7′ × 8′ = 56″ = 4′ 8″. Put down 8″, carry 4′. Then 7′ × 11 ft., etc.

175. In finding volumes, we shall, of course, have to multiply linear feet, primes, etc., into superficial feet, primes, etc.

We have

1 ft. × 1′ super. = 1 ft. $\times \frac{1}{12}$ sq. ft. $= \frac{1}{12}$ cu. ft. = 1 cu. prime.

1 ft. × 1″ super. = 1 ft. $\times \frac{1}{12^2}$ sq. ft. $= \frac{1}{12^2}$ cu. ft. = 1 cu. second, and so on.

Again,

$1' \times 1'$ super. $= \frac{1}{12}$ ft. $\times \frac{1}{12}$ sq. ft. $= \frac{1}{12^2}$ cu. ft. = 1 cu. second.

$1' \times 1''$ super. $= \frac{1}{12}$ ft. $\times \frac{1}{12^2}$ sq. ft. $= \frac{1}{12^3}$ cu. ft. = 1 cu. third.

Example. **Find the volume of a rectangular solid whose dimensions are 6 ft. 5½ in., 5 ft. 7 in., and 3 ft. 4 in.**

5 ft. 7′
3 ft. 4′
16 9′
1 10′ 4″
18 sq. ft. 7′ 4″
6 ft. 5′ 6″
111 cu. ft. 8′ 0″
7 9′ 0″ 8‴
9′ 3″ 8‴
120 cu. ft. 2′ 4″ 4‴
= 120 cu. ft. (288 + 48 + 4) cu. in.
= 120 cu. ft. 340 cu. in. *Ans.*

EXPLANATION. Multiply 5 ft. 7′ by 3 ft. 4′, as in Ex. 1 of the last article, obtaining 18 sq. ft. 7′ 4″.

Next, 6 ft. 5½ in. equals 6 ft. 5$\frac{6}{12}$ in., or 6 ft. 5′ 6″.

Then, 6 ft. × 4″ = 24″ = 2′, 6 ft. × 7′ = 42′, and 2′ = 44′ = 3 cu. ft. 8′, and so on.

Answers to Arithmetic

EXAMPLES 19

1. A square field, of the same breadth as that in the question, would contain 30 acres ÷ 3 = 10 acres = 48400 sq. yd.

Therefore, Breadth of the field = $\sqrt{48400}$ = 220 yd. The length = 3 × 220 yd. = 660 yd.

2. Area of paper required = 2 (17¾ + 13¾) × 10 sq. ft. = 2 × 31½ × 10 sq. ft

$$\therefore \text{ Length required} = \frac{2 \times 31\frac{1}{2} \times 10}{1\frac{3}{4} \times 3} \text{ yd.}$$

Hence,

$$\text{Cost} = £\frac{2 \times 63 \times 10 \times 4 \times 8}{2 \times 7 \times 3 \times 12 \times 3 \times 20} = £1\ 6s.\ 8d.$$

3. Carpet costs 3s. 3d. more per square yard than oilcloth. To cover the whole border with carpet costs £3 18s. more than to cover it with oilcloth. ∴ No. of square yards in the border = £3 18s. ÷ 3s. 3d. = 24 sq. yd. = 216 sq. ft. Area of floor = 21 × 21 = 441 sq. ft. ∴ Area of carpet = 441 − 216 = 225 sq. ft. Side of carpet = $\sqrt{225}$ = 15 ft. Hence, width of the border = (21 − 15) ÷ 2 = 3 ft.

4. Area of the four sides of the cistern = 2 (6 + 4) × 3 = 60 sq. ft. Area of bottom = 6 × 4 = 24 sq. ft. No. of square feet of lead required = 60 + 24 = 84 sq. ft. = 84 × 8 ÷ 112 cwt.

$$\text{Cost} = \frac{84 \times 8 \times 61}{112 \times 6} \text{s.} = 61\text{s.} = £3\ 1\text{s.}$$

5. Each of the walls would be 2 × 1½ = 3 times the area of the corresponding wall in the actual room. The cost would therefore be 3 × £2 17s. 9d., or £8 13s. 3d.

6. No. of square yards in the field = £852 0s. 10d ÷ 10d. = 20449. ∴ Side of field = $\sqrt{20449}$ yd. = 143 yd. Length of fence required = 4 × 143 yd.

$$\therefore \text{ Cost} = £\frac{4 \times 143 \times 8}{20} = £228\ 16s.$$

7. A box measuring 7 in. × 5 in. × 3 in. contains 105 cubic in. The given box contains 13125 cubic in. or 105 cubic in. × 125. Therefore, since

the volume of the given box is 125 times that of the other, each dimension of the given box is $\sqrt[3]{125}$, or 5 times, the corresponding dimension of the other. The required dimensions are therefore 35 in., 25 in., and 15 in.

EXAMPLES 20

1. A walks $3\frac{1}{2}$ miles before he meets B. This takes him $3\frac{1}{2} \times 18$ mins., *i.e.*, 63 min. ∴ B walked for $63 + 3 = 66$ min. The distance B walks is $4\frac{1}{2} + 1 = 5\frac{1}{2}$ miles. His rate is therefore $\frac{60}{66}$ of $5\frac{1}{2}$ miles per hour, or 5 miles per hour.

2. Travelling at 50 miles per hour, the train will take $\frac{48}{60}$ of an hour, or 48 min., to go 40 miles. This is 10 min. too long. It should therefore do 40 miles in 38 min. ; and, since it passes the station 2 min. late, it actually does the 40 miles in $(38 + 2)$ min. Hence, its rate is 1 mile per min., or 60 miles per hour.

3. In still water, he rows $\frac{3}{4}$ mile in $\frac{1}{4}$ hour, or 3 miles per hour. Against the stream he rows $\frac{3}{4}$ mile in $\frac{1}{2}$ hour, or $1\frac{1}{2}$ miles per hour. Hence, stream's rate $= 3 - 1\frac{1}{2} = 1\frac{1}{2}$ miles per hour. ∴ His rate down stream $= 3 + 1\frac{1}{2} = 4\frac{1}{2}$ miles per hour. This is 3 times his rate up stream; so that, to return, he will take $\frac{1}{2}$ hour ÷ 3, = 10 min.

4. The extra 2 miles of the return journey, at 10 miles per hour, takes $\frac{2}{10}$ of an hour, or 12 min. Hence, had he returned by the first road at 10 miles an hour, he would have taken $12 + 12$, *i.e.*, 24 min. less than for the outward journey. But, at 8 miles per hour, 1 mile takes $7\frac{1}{2}$ min., and at 10 miles per hour, 1 mile takes 6 min. ∴ He takes $1\frac{1}{2}$ min. less over each mile. Since he takes 24 min. less altogether, the number of miles in the first road $= 24 \div 1\frac{1}{2} = 16$ miles. Return road $= 16 + 2 = 18$ miles.

5. The train passes the man (*i.e.*, goes its own length) in 9 sec. It goes through the station (*i.e.*, goes its own length and another 88 yd.) in 21 sec. ∴ It goes 88 yd. in $21 - 9$, or 12 sec. Its rate, therefore, is 5×88 yd. in 60 sec. $= \frac{1}{4}$ mile in 1 min. = 15 miles per hour. Length of the train = distance it goes in 9 sec. $= \frac{9}{12}$ of 88 yd. = 66 yd.

6. The first man is 4 min. ahead. *i.e.*, $\frac{4}{60}$ of 9 miles, or $\frac{3}{5}$ mile. The second man gains on him 1 mile per hour. He will, therefore, overtake him in $\frac{3}{5}$ hour, *i.e.*, 36 min. The first man will have been walking $(36 + 4)$ min., and will have gone $\frac{40}{60}$ of 9 miles, *i.e.*, 6 miles.

7. 5 miles per hour = 1 mile in 12 min.; 4 miles per hour = 1 mile in 15 min. Hence, in the second half of the journey, A takes 3 min. less over each mile. Since he takes 15 min. less altogether, the second half of the journey is $15 \div 3$, or 5 miles. The whole distance is, therefore, 10 miles.

8. P burns as many inches in 2 hours (8.30 to 10.30) as Q burns in $1\frac{1}{2}$ hours (8.30 to 10). P burns for 6 hours (4.30 to 10.30) and Q burns for 4 hours (6 to 10). But P, in 6 hours, burns as much as Q would burn in $4\frac{1}{2}$ hours. Therefore, since one was an inch longer than the other, it is clear that Q was the short candle, and would have burned one more inch in half an hour. Hence, Q, burning 2 in. per hour, burns 8 in. between 6 o'clock and 10. Thus, the required lengths are, P, 9 in., and Q, 8 in.

9. Working together, A does an amount above half the work which occupies him for 1 day. When they work separately, B takes 2 days to do this extra piece. Thus, A does as much in 1 day as B does in 2 ; so that, working together, A does $\frac{2}{3}$ of the whole, and B does $\frac{1}{3}$. Hence, A does $\frac{2}{3} - \frac{1}{2} = \frac{1}{6}$ of the work in a day. ∴ B does $\frac{1}{12}$ of it in a day. Together they do $\frac{1}{6} + \frac{1}{12} = \frac{1}{4}$ of it in a day, or the whole piece in 4 days.

10. Noon on Monday to 8 a.m. on Wednesday is 44 hours. Thus, the clock loses 3 min. in 44 hours. The clock was right when it had lost 2 min., *i.e.*, after $\frac{2}{3}$ of 44 hours, or 29 hours 20 min. This will be 5.20 p.m. on Tuesday.

11. At 5, the large hand is 25 min. behind the other. To be only 14 min. behind, it must gain $25 - 14$, or 11 min. on the other. But it gains 55 min. in an hour, so that it gains 11 in $\frac{1}{5}$ of an hour., *i.e.*, 12 min. The required time is 12 minutes past 5.

12. Rate up stream $= 4\frac{1}{2} - 1\frac{1}{2} = 3$ miles per hour. Rate down $= 4\frac{1}{2} + 1\frac{1}{2} = 6$ miles per hour. ∴ To have come the other 2 miles to the original starting-place would have taken an extra $\frac{1}{3}$ hour, and the total time would be 2 hours 10 min. + 20 min. = 150 min. Since it takes twice as long to go up as to come down, the time taken to go up stream $= \frac{2}{3}$ of 150 min. = 100 min. $= 1\frac{2}{3}$ hour. Distance $= 1\frac{2}{3}$ of 3 miles = 5 miles.

13. The hare takes 3 leaps to the hound's 2, or 9 to the hound's 6. But the hound goes as far in his 6 as the hare goes in 14. The hound, therefore, gains $14 - 9 = 5$ hare's leaps in every 6 leaps he takes. Hence he gains the 60 leaps in 12×6, or 72 of his own.

14. In $1\frac{1}{2}$ hours one rides $1\frac{1}{2} \times 2 = 3$ miles further than the other. Hence, they meet $1\frac{1}{2}$ miles beyond half-way. Similarly, at the faster rate, they would meet $1\frac{1}{4}$ miles beyond half-way. Now, if the faster man had again ridden for $1\frac{1}{2}$ hours at the quicker rate, he would have gone $1\frac{1}{2} \times 2$, or 3 miles further than he rides at the slower rate. But in reality, he rides $1\frac{1}{2} - 1\frac{1}{4}$, or $\frac{1}{4}$ mile less than in the first case. Thus, 3 miles + $\frac{1}{4}$ mile is the distance he would go in the extra $\frac{1}{4}$ hour, *i.e.*, his rate would be 13 miles per hour. But, at 13 miles per hour, he goes $13 \times 1\frac{1}{4}$ miles in $1\frac{1}{4}$ hours, *i.e.*, $16\frac{1}{4}$ miles. This was $1\frac{1}{4}$ miles beyond half-way. Hence, half the distance is 15 miles, and the whole distance 30 miles.

NOTE. In Examples 15, No. 4, for "He broke 13" read "He broke 113." In the solution of this example, on page 1131, read "number of eggs he lost was 113. Hence, he sold $(750 - 113) \div 49$, or 13 eggs for 1s."

Arithmetic concluded

Group 5
CHEMISTRY
12

Continued from page 1601

INORGANIC COMPOUNDS

Some Important Oxides and Sulphides Nitrous, Nitric, Sulphurous, and Sulphuric Acids. Sulphates and Amides. Alloys and Amalgams

By Dr. C. W. SALEEBY

WE must now discuss certain important oxides and sulphides which have not hitherto been dealt with. Needless to say, here and elsewhere, we can deal only with the most important compounds.

The Two Oxides of Hydrogen. The normal oxide of hydrogen having already been discussed under the name of water, we may add a few words regarding the peroxide of hydrogen (H_2O_2), mentioned on page 693. This characteristic oxidising agent is a heavy, syrupy liquid, colourless, and with a distinctive taste. It is nearly half as heavy again as water.

Sulphuretted Hydrogen. The most important sulphide of hydrogen has the formula H_2S, corresponding to water (H_2O)—we have already seen that oxygen and sulphur should be classed together—and is a colourless gas, with the characteristic odour of rotten eggs, which owe their odour to the production of this gas from the sulphur contained in white of egg. The gas may, of course, be liquefied and frozen. It is found in the gases produced by volcanoes, and in the water of many medicinal springs, such as those of Harrogate. It is worth noting, however, that by the mere administration of sulphur itself at home the body can as easily be subjected to the action of this medicinal element as by drinking sulphurous waters. The visitor to such a place as Harrogate derives much, if not all, his benefit from factors other than the waters. If breathed, sulphuretted hydrogen is poisonous, and, as might be expected, it is combustible, forming water if there be but a limited supply of oxygen, whilst the sulphur is precipitated, but forming both water and sulphur dioxide (SO_2) if the supply of oxygen be abundant. The commonest way of producing sulphuretted hydrogen is by the decomposition of a sulphide, especially ferrous sulphide (FeS), by means of sulphuric acid. When we observe the formula of any sulphide, such as FeS, we see again the parallelism between oxides and sulphides. Amongst the other simple sulphides and oxides which are worthy of special mention there are many that have already been sufficiently dealt with. The following have not.

Bisulphide of Carbon. Carbon bisulphide, or bisulphide of carbon (CS_2), is formed by the direct union of carbon and sulphur, and is thus strictly comparable with carbon dioxide (CO_2). This, however, is a colourless liquid, which is heavier than water, and quite insoluble in it, while it gives off an extremely offensive and inflammable vapour. The products of its combustion are naturally carbon dioxide (CO_2) and sulphur dioxide (SO_2). Bisulphide of carbon is used in the manufacture of a large number of indiarubber goods which require to be vulcanised so that they may withstand changes of temperature. The process is very often performed by using bisulphide of carbon, for when indiarubber is dipped in the liquid it becomes pliant, its elasticity is increased, and it will no longer become hard. Unfortunately, the inhalation of this substance causes very serious symptoms in many cases, and if its commercial employment is still to be continued, there are two precautions which should always be taken. The first is that, since the effects are usually due to chronic poisoning, none of the workpeople should be allowed to work continuously at this part of the manufacture, but there should be alternation of employment; and the second is that the most scrupulous care should be taken in ventilation, even to the extent of using fans, so as to prevent the vapour from being inhaled.

Nitric Acid. We must now pass to consider an acid which ranks in importance with hydrochloric acid, already described, and sulphuric acid, to which we shall soon come. This is nitric acid, which has the formula HNO_3. When discussing the law of multiple proportions, on page 695, we mentioned five kinds of molecules compounded of nitrogen and oxygen. Nitric acid is to be regarded as the acid formed by the union of water and the pentoxide, as it is called —from Greek *penta*, five—of nitrogen (N_2O_5). Nitric acid, with its powerful action upon almost all substances, does not occur as such in nature, and is usually obtained by turning it out from one of its salts, called nitrates, by means of sulphuric acid. The following is the equation, which the reader will recognise as being exactly comparable to the equation we have already given for the production of hydrochloric acid from sodium chloride :

$$NaNO_3 + H_2SO_4 = NaHSO_4 + HNO_3.$$

We see that the products of the decomposition are the acid required and the same acid, sodium sulphate, as was formed in the previous instance. Sulphuric acid is more powerful than either of these others, and thus will turn them out of their compounds. Nitric acid is a powerful oxidising agent, and has very marked actions upon the human body : it stains the skin yellow. Its anhydride, as we have seen, has the formula N_2O_5, and is a white crystalline body which forms nitric acid when added to water. The reader will be able, with a little thought, to write for himself an equation that represents the change.

Laughing Gas. The peroxide of nitrogen (NO_2) is a reddish gas which probably has the formula stated at high temperatures but the formula N_2O_4 at lower temperatures, as if the effect of the higher temperature were to split into two the larger molecules which occur when the gas is frozen. This gas cannot be breathed. On the other hand, nitrous oxide, having the formula N_2O, is a colourless gas, with a not unpleasant sweetish taste and odour, which can be readily breathed, and is familiar as laughing gas. It may be made in various ways, the simplest of which is heating ammonium nitrate, which is decomposed, yielding nitrous oxide and water, according to the equation :

$$NH_4NO_3 = 2H_2O + N_2O.$$

This gas can be readily liquefied, and is sold, like oxygen, in steel cylinders, for medical purposes. It has the distinction of being, on some grounds, the oldest anæsthetic, and is very largely employed in dentistry, while it is largely coming into use in general surgery in combination with other anæsthetics. The extreme safety which attends its use, and to which it owes its value, has a very interesting explanation. The essential part of the act of breathing may be simply stated as the removal of carbonic acid from the blood, and the addition of oxygen to it. Now, most anæsthetics owe their action to some chemical combination which they form with the nervous tissue, but nitrous oxide appears to have an entirely different action. When breathed in place of air—more dangerous anæsthetics being breathed in only very small proportions in air—nitrous oxide appears to form a temporary union with the hæmoglobin, or red colouring matter of the blood, the normal business of which it is to form a similar union with oxygen.

Action of Laughing Gas. Thus the nitrous oxide completely deprives the nervous tissues of that constant supply of oxygen which is necessary for consciousness. On the other hand, the gas does nothing whatever to interfere with the other half of the process of breathing—the removal of carbonic acid from the blood. In accordance with the laws of partial pressure [see PHYSICS], this process freely continues while the gas is being inhaled, and it is because the process is so extremely simple, and because the removal of the poison is not interfered with, that this gas is so extremely safe. But, of course, it cannot act for long ; as soon as the mask is taken away, and the patient breathes ordinary air, the pressure of the nitrous oxide in his blood becomes far higher than the pressure of the minute quantity of nitrous oxide that may be in the atmosphere, and so the gas is rapidly exhaled, and under ordinary conditions the dentist cannot very well count on much more than a minute of anæsthesia. A very simple and significant experiment will serve to show the possible truth of the suggested explanation of the anæsthetic value of nitrous oxide as due to depriving the nervous tissues of their oxygen. If one eye be shut and the other be firmly pressed by the finger through the eye-lid whilst remaining open, in a very few seconds all objects will entirely disappear. The explanation is that the pressure of the finger has momentarily prevented the blood from circulating through the retina, or nervous curtain at the back of the eye, in which, without a continuous supply of oxygen, sensation cannot be aroused. It has lately been shown that if a high proportion of nitrous oxide be breathed together with air, anæsthesia for much longer periods than a minute can be maintained with great safety, suitable for operations elsewhere than on the mouth. When the gas is breathed in marked dilution, however, it produces much exhilaration, whence its name.

Nitrous Acid. In contrast with nitric acid (HNO_3), we must make the acquaintance of nitrous acid, which has the formula HNO_2, and the anhydride of which, nitrous anhydride, has the formula N_2O_3. This is a dark-blue liquid which is extremely unstable, and cannot exist at all in the gaseous state, but which, with ice-cold water, forms nitrous acid. The reader can easily write an equation for himself which will prove that a molecule of water and a molecule of nitrous anyhdride, if combined, must yield two molecules of nitrous acid. Just as nitric acid forms nitrates, so nitrous acid forms salts, which are called nitrites.

The series of nitrites in general have a very remarkable action upon the body, an action which was first observed in the case of the organic nitrite called amyl nitrite, but is shared by such salts as sodium nitrite. The common property of all these substances, whether organic, inorganic, liquid, gaseous, or solid, is to cause immediate and marked relaxation of all kinds of involuntary muscular tissue in the body—an action not yet explained ; but it is to this that they owe their remarkable and almost unique value in the treatment of pain of the heart, asthma, and all forms of colic.

Sulphur Dioxide. Sulphur and oxygen form two very important combinations with each other. One of these is sulphur dioxide, or sulphurous anhydride, already referred to, having the formula SO_2 ; whilst the other is sulphur trioxide or sulphuric anhydride, which has the formula SO_3. Sulphurous anhydride, together with a certain quantity of the trioxide, is formed when sulphur is burned in air, and is the agent of fumigation, or disinfection, by sulphur. It is a colourless gas with an extremely pungent smell, much more powerful but less disagreeable than that of sulphuretted hydrogen. It is a true disinfectant, being antagonistic to all forms of life. But this is not to say that the fumigation of a sick-room by means of sulphur, as ordinarily practised, is anything but a pitiable and dangerous farce. It is one of the first axioms of natural philosophy that a thing cannot act where it is not. Readers of the course on PHYSICS will remember our difficulties in this respect in relation to the force of gravitation. Similarly, sulphur dioxide, though an excellent antiseptic, cannot act where it is not, and, as a rule, it never reaches those very places where the microbes of disease are hidden. In order to utilise properly its disinfectant powers, a room should first be practically emptied and should then have a very large quantity of sulphur burnt in it, while all outlets for the gas are rigorously closed. This may most unpleasantly affect the appearance of the room, but it will be effective. The kind of fumigation that does not hurt the room does not hurt the microbes.

Sulphurous Acid. We have called this gas an anhydride, and its acid, of course, must have the formula H_2SO_3, which is obviously obtained by adding together the formulas of water and sulphur dioxide. At low temperatures this acid is stable, and is thus comparable with nitrous acid. It forms sulphites just as nitrous acid forms nitrites, a typical example being sodium sulphite, which naturally has the formula N_2SO_3. Sulphurous acid is a weak acid and is readily turned out of its compounds by means of other acids, such as sulphuric acid or hydrochloric acid.

Sulphur Trioxide. Sulphuric anhydride, or sulphur trioxide, SO_3, is a white crystalline solid. It is less stable than sulphur dioxide, and one atom of sulphur can be persuaded, so to speak, to combine with three rather than with two atoms of oxygen, only if the conditions are made specially favourable. The trioxide is decomposed into the dioxide and oxygen at the temperature at which sulphur burns, and hence cannot be produced by this means. But if a mixture of dry sulphur dioxide and oxygen be passed through a red-hot tube coated with platinum, the trioxide is formed by one of those most curious actions which resemble those of a ferment, and are often called catalytic. When we discussed platinum, we noted the singular chemical properties which it possesses, being able, for instance, to induce such chemical actions as the direct union of oxygen and hydrogen at ordinary temperatures. It was there argued that in all probability the platinum acts by breaking up a certain number of the gaseous molecules, so that the atoms thus divorced are liable to seek new partners. The formation of sulphur trioxide is another illustration of this argument.

Sulphuric Acid. We have called the trioxide an anhydride, and on combination with water it forms the very important acid known as sulphuric acid (H_2SO_4), the formula of which is obviously obtained by adding together a molecule of water and a molecule of the trioxide. Of such great importance is this acid that the amount of it that is used in any country can be employed as an index of its measure of material civilisation. At least this is what has been more or less jokingly said, and certainly many means of judgment much less accurate are often employed. It might be thought that the easiest way to prepare sulphuric acid (which does not occur in nature) would be to oxidise directly sulphur dioxide, meanwhile adding water to it, but owing to the cause we have already named, this is not possible. The actual process of manufacture is of some complication. The essential principle is that sulphur dioxide is obtained by burning iron pyrites (FeS_2), and that by means of nitric acid fumes the dioxide is further oxidised into the trioxide, the oxides of nitrogen in the fumes acting as oxygen carriers. When the pure acid is finally obtained it is found to be a thick, colourless, heavy liquid, which has an extraordinary affinity for water, so much so that it is practically impossible to obtain sulphuric acid that is entirely free from water.

Anhydrous Sulphuric Acid. It is unsatisfactory to say, as is often said, that it is impossible to obtain "anhydrous sulphuric acid," because we might reasonably expect that term to indicate sulphur trioxide. At any rate, this acid forms true compounds with water, which may perhaps be called hydrates. When it is mixed with water, not only does the resulting product occupy less volume than did the water and the sulphuric acid before they were mixed, but there is also the evolution of much heat, which, as the doctrine of the conservation of energy teaches us, has to come from somewhere, and which implies the satisfaction of potential chemical energy previously present in the sulphuric acid and the water, and the transformation of that energy into the form of kinetic energy which we call heat [see PHYSICS].

Uses of Sulphuric Acid. Thus, sulphuric acid may be used in order to dry gases and other bodies, and probably the most marked of its properties in relation to living matter are due far less to its character as an acid, though this is marked enough, than to its character as a withdrawer of water, or a dehydrator. This process of dehydration, or the removal of water, causes the characteristic marks of the action of sulphuric acid—we saw that nitric acid turns the skin yellow; pure sulphuric acid makes it black, and has the same action on wood and sugar. Indeed, it chars these substances, and the black is simply carbon, or charcoal.

The case of sugar is the simplest because this, as we shall afterwards see, is a carbohydrate—that is to say, a substance consisting of carbon, hydrogen, and oxygen, the two latter being present in the same proportions as they are in water. Thus, to speak somewhat loosely, the reason why sulphuric acid chars sugar is that it removes all the water—strictly speaking, the elements equivalent to water—that enters into its composition, leaving merely the charcoal behind. The acid has countless practical uses—in the preparation of other acids, as we have already seen, in the manufacture of sodium carbonate and caustic soda, these being quoted from hundreds.

One peculiar use may be mentioned because of its chemical interest. When we were discussing lead we saw that certain of its soluble salts may be taken into the system, either in drinking water or by contamination with the food from the fingers of workers in lead. We commented upon the need for scrupulous washing of the hands before eating in such cases. Here we may add that a recognised device for preventing lead poisoning amongst workmen is the drinking of what is rather ironically called "sulphuric acid lemonade." This is essentially a very weak solution of sulphuric acid in water, and it owes its virtues to the fact that the acid, acting on any compounds of lead that may have been swallowed, will form sulphate of lead, which is insoluble, and which, therefore, not being absorbed, is entirely harmless.

Sulphates. Certain sulphates have already been referred to. We may note the names of *calcium sulphate* ($CaSO_4$), which, under varying conditions, is known as gypsum, alabaster, and plaster of Paris; *magnesium sulphate* ($MgSO_4$), which abounds in the mineral springs at Epsom, and hence is called Epsom salts; *zinc sulphate*, which is an antiseptic and astringent, and thus also of value in medicine; *ferrous sulphate* ($FeSO_4$), which, having nothing to do with copper, is unfortunately known as *copperas*, or, much better, as *green vitriol*; *copper sulphate* ($CuSO_4$), known as *blue vitriol*—the term "vitriol" or "oil of vitriol" being often applied to strong sulphuric acid. The word is derived from the Latin *vitrum*, glass, since the acid and many of its compounds in certain states have a glassy appearance. But there is a further class of sulphates to which special reference must be made.

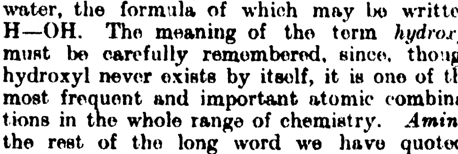
Alums. The word *alum* is very frequently confined to what should properly be called potash alum; but, in the general sense, an alum is a double sulphate consisting of the sulphate of one of the alkali metals, together with a sulphate of aluminium or one of the metals belonging to the aluminium group. They all correspond to potash alum, the formula of which is variously rendered, as intelligible a reading as any being $KAl(SO_4)_2, 12H_2O$. They all form eight-sided crystals, so that if a crystal of one of the alums be placed in a solution of another, the crystal is covered by a crystalline layer derived from the solution. This is made the more easily possible since they all contain the same number of molecules of water of crystallisation. All the alums are readily soluble in water, they all have an astringent taste, and an acid reaction to litmus paper and the like. Thus, in every way, they form a very definite class. The most important alums, after potash alum, which has been so long known, are those containing ammonia, chromium, iron, and manganese. The chief use of ordinary alum—that is to say, potash alum—is as what is called a mordant (from the Latin *mordeo*, I bite)—that is to say, a substance which so affects cloth dipped into it that any colouring matter afterwards employed stains the fibre much more permanently. This is due to the relation of alum to colouring matters, with which, as we have seen, it forms the precipitates called *lakes*.

Many other oxides are of importance, and some of them have been previously referred to, but we must pass them and discuss a few other compounds, which are mostly of small importance in themselves, but are of interest because some of them introduce us to fresh complexities, the memory of which may help us when we pass on to the chemistry of the carbon compounds.

Derivatives of Ammonia. Ammonia (NH_3) may, of course, be described as a nitride of hydrogen, and in referring to the alkaloids we have seen the theoretical importance of this substance, since one or more of the hydrogen atoms may be replaced by innumerable atomic combinations, such as those which constitute the alkaloids. But there are other nitrides of hydrogen. That which has the formula N_2H_4 resembles ammonia, and is known as hydrazine.

Of much greater interest is the compound with the formidable name *hydroxylamine*. This name, however, has good sense in it. The first part of it, *hydroxyl*, is applied to the atomic group, $-OH$, which is found in combination with so many other kinds of atoms and groups of atoms, the simplest case, of course, being water, the formula of which may be written $H-OH$. The meaning of the term *hydroxyl* must be carefully remembered, since, though hydroxyl never exists by itself, it is one of the most frequent and important atomic combinations in the whole range of chemistry. *Amine*, the rest of the long word we have quoted, is the name of an almost equally important atomic group, NH_2. Hence the formula of hydroxylamine is given in its name, once the meaning of the name is explained. It is, of course, NH_2OH. Now, suppose this were written in the shortest possible way, it would run NH_3O, and there would be no comprehension of the presence of the oxygen atom, but if we write it properly, NH_2OH, we see that this substance may be regarded as ammonia, one hydrogen atom of which has been replaced by hydroxyl. We may even, by way of illustrating the meaning of the graphic formulas to which we must soon come, venture on a little drawing to show what may be supposed to have happened. The lines represent the "hands" of the atoms:

Hydroxylamine is known in solution in water as an alkaline liquid. When this is distilled some of it passes off unchanged, while the rest is decomposed, forming ammonia. As may be expected, if we compare the formula of hydroxylamine with, say, the formula of caustic potash (KOH), this substance is an alkali and forms salts with acids. In looking at the formula of caustic potash, the reader will recognise the last two letters as constituting the hydroxyl group.



The Amides. Hydroxylamine is also of importance, as we may use its formula in order to remind ourselves that hydroxyl and amine can take each other's places in various compounds. For instance, there are known compounds called *sodamine* and *potassamine*, the formulas of which are $NaNH_2$ and KNH_2, obviously corresponding to $NaOH$ and KOH, the amine group having taken the place of the hydroxyl group. These are simple instances—zinc amide, $Zn(NH_2)_2$, being only slightly more complicated—of the countless compounds of ammonia. Another, which is of importance because it is so often put to practical ends, is the substance which is popularly known as *white precipitate.* This is a compound of ammonia and perchloride of mercury or corrosive sublimate and its formula may variously be written If a solution of corrosive sublimate act upon ammonia, this body is formed. Its composition may be most conveniently written NH_2HgCl—the reader will remember that $HgCl_2$ is the formula of perchloride of mercury, not $HgCl$. This last, however, is the formula of the subchloride of mercury, or mercurous chloride, and this has a similar interaction with ammonia, forming a substance of no importance.

Phosphoretted Hydrogen. Phosphorus, we remember, belongs to the nitrogen group of elements, and so, if the grouping of the elements means anything, we may reasonably expect that there should be compounds of the other elements of this group with hydrogen, corresponding to the compound ammonia, and this is so. For instance, we know the phosphorus compound, which naturally has the formula PH_3, the arsenic compound (AsH_3) and the antimony compound (SbH_3).

Of these, by far the most important is phosphoretted hydrogen, often called phosphine (the others are similarly sometimes known as arsine and stibine). Like ammonia, phosphine is a colourless gas, poisonous, having a horrible smell, but, unlike ammonia, insoluble in water. It may be formed in various ways—as, for instance, by boiling a strong solution of caustic potash containing free phosphorus. In these and other methods of manufacture, great care has to be taken to dispose of another phosphide of hydrogen (P_2H_4), which is liquid and very inflammable, even at ordinary temperatures. A third compound, containing still more phosphorus in proportion, is solid (a red powder) and has the formula P_4H_2. Now the parallelism between phosphine and ammonia is still further illustrated by the fact that with certain acids it forms salts which precisely correspond to the salts of ammonium. For instance, there is the salt called phosphonium bromide, which has the formula PH_4Br, and which exactly corresponds, both in its mode of formation and otherwise, to ammonium bromide (NH_4Br).

Alloys and Amalgams. Last among inorganic compounds we may refer to the alloys and amalgams, and in the first place it is necessary for us to recall the very dogmatic statements we made on page 692 regarding the difference between a mixture and a compound. If that difference were a real one, then we must apply the test which it furnishes to these bodies and must so ascertain the class to which they belong. The difference between an amalgam and an alloy is only one of convenience, the former word being used, as we have seen, to indicate a metallic mixture or compound which contains mercury, and the latter to indicate one which does not.

Now certain alloys—by which for the moment we will include amalgams—do not answer at all to our test of a compound. There is no chemical combination because, for one thing, there is no definiteness of composition. The law of fixed proportions is not observed. These may, therefore, be regarded as solid solutions of one metal in another. On the other hand, certain alloys have a real claim to rank as compounds, while a large number are partly composed of a true compound and partly of a mere mixture. In discussing steel, we saw how great may be the practical difficulties of determining the exact line at which we are entitled to call a substance a compound rather than a mixture. What, for instance, constitutes the difference between cast iron and steel, if it is not that in the latter the carbon is combined with the iron?

And then the question arises whether we should not rather say that the carbon is dissolved in the iron, steel being thus a solid solution of one element in another. Of course, carbon is not a metal, and so steel is not strictly an alloy, but hydrogen has long been regarded as either a metal or the equivalent of a metal, though Sir James Dewar's production of solid hydrogen, which does not resemble a metal in any way, scarcely consorts with that long-held theory. For convenience, however, we may regard the compounds of other metals with hydrogen as alloys, and so, under this heading, we may note the hydride of sodium (Na_2H), which is formed by the interaction of hydrogen and sodium; the alloy between iron and hydrogen, found in many meteors; and the extraordinary alloy between palladium and hydrogen.

Some Remarkable Alloys. Palladium, the reader will remember, is classed with platinum, and the remarkable absorption of gases by this latter metal has already been described. Now, palladium absorbs, or we may say unites with, not far short of a thousand times its own volume of hydrogen to form a body to which we may allot the formula P_2H. This is a metallic body which must be called an alloy, and it is decomposed by heat, the absorbed or combined hydrogen being liberated.

The very interesting ammonium amalgam has already been described, because it affords us some proof of the existence of the supposed compound metal, ammonium. Parallel with it is sodium amalgam, which is doubtless not to be regarded as a true compound. To numerous other alloys we have already made references, especially to bronze, which is of such great historic interest, but completely to treat of the subject of alloys, or even to do so for the practical man alone, would require a course in itself.

We can allot no further space to the discussion of inorganic compounds. The colossal and daily growing subject of radium and radioactivity, unknown to the ordinary text-book of the past and really of more importance than anything with which they dealt, is yet before us, and can by no possibility be briefly disposed of. Hence, without further delay, we must proceed to a discussion of the laws of chemistry, to which we have made only incidental reference hitherto, since the logical method, and the method by which the laws were actually discovered, is first of all to ascertain the facts, and then to infer the laws from them.

Continued

FORMING THE SLIVER

Gilling and Combing Worsted Wools. The Machines and their Operation. Spreading Flax. Making Silk and Ramie Slivers

Group 28

TEXTILES

12

Continued from page 1548

By W. S. MURPHY

Gilling and Combing. Wools of long staple cannot be treated on the carding engine; fibres like the wools of the vicuna, alpaca, Angora goat, Lincoln sheep, and others of the long-woolled animals, would only tangle and break on the teeth of the cards. Further, the character of the worsted thread requires that the fibres should be made to lie even and parallel—an object not exclusively aimed at in carding. We have need, therefore, of a machine which will do for the long wools what the scribbler does for the short wools. This is supplied by what are named *gill-boxes*.

Gilling Machine. Gilling is a minor operation, but as it operates on principles used in other departments, a short survey of the machine may be profitable. The main parts of the gill-box or gilling machine [64] are a feed-board, fluted feed-rollers, a series of combs set in slides, screws parallel to the feed-rollers, and drawing-off rollers at the end. Feed in the wool and put on the drive. The rollers take in the wool and deliver it to the parallel comb; the comb travels forward, followed by combs similarly acting, which, while drawing off their own shares, support the ends of the wool held in the teeth of the first combs. In this procession they go till almost touching the drawing-off rollers; the moment the fibres are taken hold of by these last, the comb drops down, deserts its fibres, and returns to the point of starting; the other combs perform in the same way. Note the effect. The feed rollers travel slowly, delivering wool at less speed than the combs would take it, and they therefore draw it out. The drawing-off rollers run at a speed still higher, and pull the fibres out of the teeth of the combs, giving the wool a further dragging, and, as a consequence, refining.

Combers. Usually, a balling apparatus is attached to the gilling machine; but either in the form of the balled coil of the gill, or the coiled sliver from the carder, the wool is now taken to the combing machine. Among the many combing machines we feel rather embarrassed; they are not so many copies of an expired patent, but honest expressions of ingenious ideas. The history of no machine that we know contains so many names worthy of respect: Heilmann, Donisthorpe, Lister, Preller, Crab, Platt, Noble, Holden, and M'Naught, to mention only a few. Most of these names represent a different machine, and we cannot undertake to study each one of them. The root principle of all, however, is contained in the original invention of M. Josue Heilmann, a French native of Alsace, and to it we shall turn our attention first. The central part of this machine is a cylinder, divided into four sections, two with teeth, and two plain; projecting from the outer side of the machine hang a pair of large nippers, between the legs of which sits a combing guide; at the side of these run a pair of rollers, movable from the position beside the nippers down to the front of the cylinder.

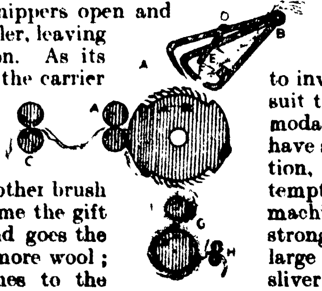
Heilmann's Combing Machine. In this machine, shown in 65, the sliver is fed on to the guide combs D, E, and passes in between the open jaws F of the nippers B; as soon as enough wool has passed, the nippers close down; a tuft of fibre projects, and of this the toothed section of the centre cylinder seizes hold, drawing it out, while the nippers also hold. The plain section of the cylinder comes round and sets the drawing rollers A going by friction, and these pull in the wool while the nippers relax their grip, with the same action pressing the wool well down on the guide combs D, E. In those acts a combing action is apparent, but it is not enough. The drawing rollers A swing round and present the other ends of the wool to the second toothed section of the cylinder, and it pulls firmly at them; the plain section of the cylinder succeeding, it gives the drawing rollers an opposite turn, and they draw out the wool to the delivery rollers C. Under the large cylinder works a doffing apparatus (G and H), which clears off the noils, or remaining fibres, from the teeth of the cylinder.

Lister's Patent Combing Machine. Even before it had been very well known in this country, the French inventor had considerably improved on the simple model we have examined; but the principles were not altered. Whether original or imitative, it is impossible to say, several combing machines on the nipper principle began to appear on the market. The most noteworthy of these was the combing machine of Messrs. Lister, of Manningham. Though so vastly improved as to be practically a new machine, Lister's combing machine was adjudged by the British Courts to be an infringement of Heilmann's patent. Messrs. Lister bought up the Heilmann patent rights for £30,000, and never used them. The Lister combing machine is circular in form, and a large proportion of the combs of other inventors are also of that shape. We shall therefore try to study the general structure of the circular combing machine as such, without special reference to any particular patent.

Circular Combing Machine. Round the circle of the machine [67] are the combs C, and within are the screw-gills BB, brushes, and other appliances. Acting on each other and the wool in a rather complex way, the parts of the machine require to be observed very carefully in motion.

64. DOUBLE HEADED GILL-BOX, WITH TWO SETS OF SCREWS AND FALLERS FOR THE WORSTED TRADE (Taylor, Wordsworth & Co., Leeds)

The wool sliver is fed into a screw gill-box similar to that we saw in the gilling machine ; but the variations are important. The gills or faller-combs, as they are named because of their falling action, are closely set with fine teeth and slightly depressed in the centre; above the faller-combs a dabbing brush (A) is geared on an eccentric cam, so that it moves up and down on the top of the comb. Borne forward on the faller-combs, the wool is brought up to a pair of nippers (D); as it moves toward the latter the brush descends and drives the wool deeply into the comb teeth. The upper jaw of the nippers is a fixed blade ; the lower jaw is the movable part, a groove in the latter forming the channel for the upper blade. Swift action now takes place. The faller-combs close up to the nippers ; the jaws close over the tuft of wool ; the faller drops to give place to its successor, leaving the wool in the nippers with a dragging motion ; the nippers (D) swing away and encounter a carrying comb (E), which catches on to the tuft of wool ; the nippers open and swing back to meet another faller, leaving the carrier comb in possession. As its name implies, the functions of the carrier comb is merely to bear the wool from one point to another. It turns over to the circling comb C, the teeth of which accept the wool, and another brush (G) comes down and drives home the gift of the carrier servant. Round goes the circling comb, receiving ever more wool ; but in its movement it comes to the drawing rollers, which pull the fibres from its teeth and form them again into a continuous sliver. An illustration of an improved machine is shown in 67.

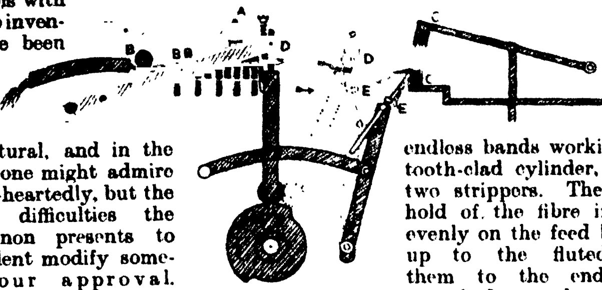


65. HEILMANN'S COMBER

It will readily be perceived that the combing machine has been well designed for its function. Combed from the fallers, combed from the carrying comb, and finally combed from the circling comb, the fibres are made straight and parallel.

Other Combing Machines. In most of the principal details the other models of combing machines closely resemble the kind described. One machine, however, largely used, differs so much from the others that it should be observed. On the end of this machine [68], which is named the "Eastwood," the wool is laid in laps. Drawn out from the lap by a series of gill combs, the wool is borne forward to a nipper, which draws it out of the gill teeth, and so combs the one end. From the nippers the fibre is borne and thrown over the circling comb. On the outside of the circle the drawing rollers are keeping watch over the comb, and as it comes round with its spoil they pull the wool through from its teeth, combing the other end, and leaving the noils inside the circle, whence they are carried away by knives and deposited in a can placed to receive them. The sliver is wound on to a ball, to be ready for the drawing process. This machine does very well for short wools and cottons. Regarding the combing of the latter it is needless to say much. Of course, the comparative shortness of the longest cotton fibres presents some difficulty, but that has been overcome, with remarkable success, by adapting the combing machine to the short staple.

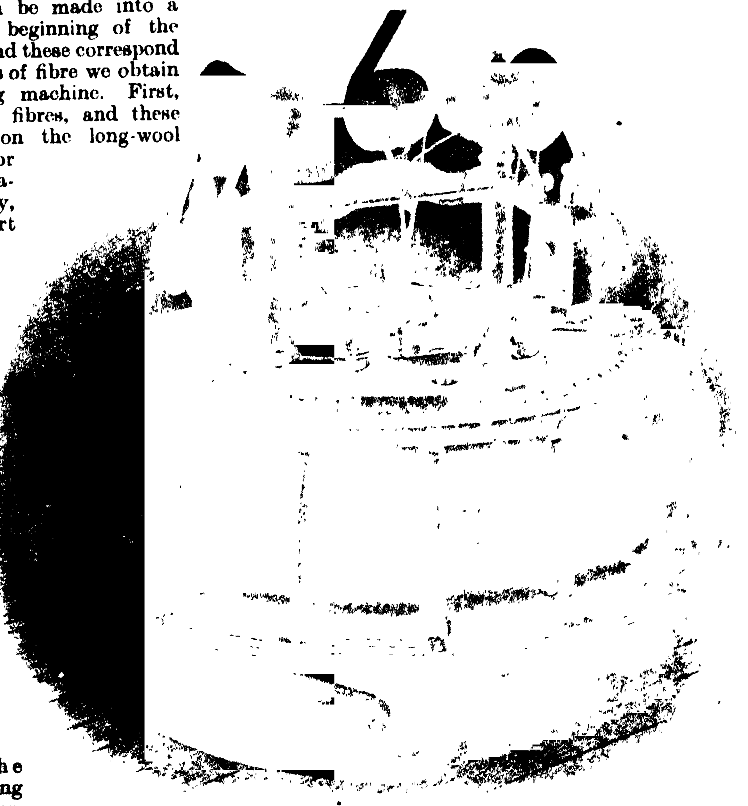
Slivers of Waste Silk and Ramie. The younger fibres of the textile world are sometimes unjustly treated. We have such a wealth of machines already, it seems wasteful to invent special contrivances in order to suit them. Waste silk has been accommodated with special machinery, as we have seen, in the earlier stages of preparation, but in the latter processes the temptation to utilise or adapt the machines already in use has proved too strong. Thus it has come that we find a large variety of machines forming the sliver of waste silk. As a rule, the principle of local adaptation works most strongly. In cotton-manufacturing districts cotton machinery is utilised ; in the woollen districts wool carding and combing machines serve the purpose ; in a factory here and there special machines have been contrived, but even these have very little originality about them, and are mostly combined borrowings from those tools with which the inventors have been most familiar. Nothing could be more natural, and in the abstract one might admire it whole-heartedly, but the bristling difficulties the phenomenon presents to the student modify somewhat our approval. Roughly speaking, waste silk is treated here, in the cotton districts, like cotton, and there, in the woollen districts, like wool; but when we come to strict practice, those generalities will not work. You cannot put a batch of waste silk material through the cotton card just after a run of cotton. Leaving these generalities, therefore, let us get down to particulars.



66. LISTER'S COMBER

Long, Medium, and Short Silk Fibres. There are three ways in which the raw material of waste silk can be made into a sliver fit for the beginning of the spinning process, and these correspond to the three classes of fibre we obtain from the dressing machine. First, we have the long fibres, and these are best treated on the long-wool combing machine, or a partial modification of it. Secondly, there are the short fibres, which can be very well dealt with by the finisher card of the long-stapled cotton, if the cylinder be properly set to suit. Thirdly, we have left the noils, which will readily pass through a carder set for coarse cotton or short-stapled wool.

Silk Carder. But we are not altogether dependent on the machines belonging to other textiles. One machine has been built specially for long-stapled, strong fibres, and may be used for the sliver of waste silk and ramie, all that has been said previously applying to the latter fibre as well. This is a very compact and serviceable machine. Its principal parts are an endless feed sheet, a pair of fluted rollers, a pair of tooth-covered endless bands working over each other, a wide tooth-clad cylinder, with a worker roller and two strippers. These parts successively take hold of the fibre in the usual course. Laid evenly on the feed band, the fibres are carried up to the fluted rollers, which deliver them to the endless carding sheets, each stretched round two rollers. Running at a higher speed than the feed rollers, the sheets draw out the fibres and divide them finely. The great cylinder in the centre is going at high speed, and its teeth draw away the fibres from the endless sheets. Looking at the way the cylinder takes on the fibres, one would almost think that the doffer would be enough to finish off the work; but the operator has found that something more was needed, and so we have the worker and strippers. These rollers



67. CIRCULAR COMBING MACHINE (Taylor, Wordsworth & Co., Leeds)

play in the give and take style of their kind, refusing to let any fibre pass till the cylinder has it lying straight and even. Then the doffing apparatus comes into play, and forms the fibres into a long, filmy sliver.

Knots in Waste Silk. Ramie, as we have said, is at present subjected to the same treatment as waste silk. In must be added, however, that the newer fibre responds more readily to the wishes of the operator. When we have got the latter into a sliver, it is altogether smoother and finer than waste silk fibre. While the latter has within it many little knots and irregularities, defiant of all our care, ramie is very smooth and glistening. That is to say, the silk fibres are even enough, but on each individual fibre there remain small and, as yet, imperceptible knots, which are certain to give trouble in the future. If it were possible to make yarn out of only two or three of the fibres, the small irregularities might not matter ; but we have to remember that it takes nine or ten of the fibres to form our thinnest yarn thread. An imperceptible defect, if multiplied ten times, will become a very apparent one. Put two points one degree beyond visibility together, and they are perceptible ; add another eight, and they will have become a knot of considerable dimensions. That is one of the facts against which we have to contend all through the manufacture of the finer textiles. Waste silk fibre shows a combination of knots very prominently, and special means require to be adopted to clear them away. On the other hand, ramie is singularly free from that defect, the fibres being finely regular in structure. After the sliver of ramie has been formed, the spinning process is very straightforward.

Spreadboard. This machine [69], which performs for flax the same service as the carder does for cotton and wool, has imparted to textile-machine makers many of their best ideas. The silk-filling engine, the various combers, and several other machines, owe some of their most important parts to the spreader of the flax line. *Line* is the name we give to that flax which has survived the hackling, and the short fibre is called *tow*. Tow is dealt with in a different way, as we shall see. Line is the best of the flax. From the sorters' benches it is brought to the spreader in bundles of stricks carefully kept individual. The worker who attends the machine has the flax stricks laid down beside the machine within easy reach, for this machine is still fed by hand. What is the precise reason for continuing the hand feed we hardly know. It is nonsense to say that no mechanical appliance is equal to the task ; on the contrary, the weighing principle which is applied to the finished sliver would greatly aid the accuracy of the work if it were applied to the feeding apparatus. This may be too bold. Let us, therefore, hasten to look at the machine itself.

A spreadboard consists of five principal parts : (1) The holding rollers, which take the flax from the feed-board and deliver it slowly to the gills or faller-combs ; (2) the screw-gills, or faller-combs ; (3) the drawing rollers ; (4) the doubling bars, which are not bars at all, but a single plate of metal through which are cut diagonal slits, inclining to an angle of 45° ; (5) the delivering rollers, which convey the sliver to the cans standing at the end of the machine.

Motion of Gills. Looking more closely into the machine, we see that the gills, or combs, are set upon screw-bars running parallel with the sides of the frame. There are two sets of screw-bars, one above the other. When the combs have reached the end of the upper bar they drop down on to the second, and, travelling along the reversed screw, get back to the point of starting, where by a cam movement the lower bar lifts them up to the level of the top screw, on which they resume work.

There are a few other peculiarities in the machine, but these can best be observed in the working. The stricks are laid evenly on the feeding apron, which is an endless band, like all textile feed-bands, though this one is generally made of leather. The feeder must carefully watch not to toss the fibres or disarrange them in any way, laying the root ends in first, and the end of each successive strick well up to the middle of the one before it, so as to make sure of a continuous line of fibres.

Combing the Flax. Beyond the feed-band is a series of vertical steel plates, well named conductors, which keep the fibres straight and guide them to the feed-rollers. Passing through the feed-rollers, the flax is taken hold of by the gill-combs, a row of which just come bobbing up at the proper moment, and they carry forward the fibres with a spiral motion, opening out, combing and drawing, as they go along. Arrived at the drawing rollers, the combs bid adieu to the fibres, dropping down, while the swiftly running drawing rollers pull the fibres in. Revolving at a greater speed than the feed-rollers, the drawing rollers elongate the fibres, and give them out in the form of flat, slender ribbons to the doubling bars. Being set at an angle, the slits in the doubling plate, or bars, direct the slivers in a

68. EASTWOOD COMBING MACHINE
(Platt Bros. & Co., Oldham)

69. FLAX SPREADER (Combe, Barbour & Co., Belfast)

rectangular path, thus enabling the delivery rollers to present them in such a line that the sliver roller may combine them and send a single sliver into the can standing at the end of the machine. In the form of a soft, thick rope the flax falls in coils into the can.

Bell-gauge. Upon the end of the delivery roller is geared a small worm which runs into a wheel. This wheel acts on another wheel actuating the spring of a bell. The worm winds out with every revolution of the delivery roller, till it comes into gear on the wheel, which it turns. The wheel, in turn, acts on the bell-wheel, and the bell rings. By this device the exact length of the sliver can be determined. If the spreader has been properly adjusted, and the feed regulated according to design, the exact weight of a given length of sliver can be ascertained. All the factors, however, need to be taken into account—the rate of the various rollers, the movements of the faller-combs, and the gearing of the delivery rollers. Experience alone enables the worker to accomplish this difficult achievement.

Continued

Group 4
BUILDING
12
CEMENT MANUFACTURE

continued from page 1585

CEMENT BURNING & GRINDING

The Various Types of Kilns. Their Operation and Merits Considered. Kinds of Fuel Used. Coal Grinding

By CLAYTON BEADLE and HENRY P. STEVENS

WHEN the raw materials have been finely and intimately mixed, either in the shape of slurry by the wet process or as raw meal in the dry process, they have to be subjected to a "calcination" or burning at a high temperature.

The rotary kiln, which is now being generally introduced for this purpose, has, among other advantages, that of taking the raw materials in the shape in which they come from the raw mill, whether as slurry or raw meal, direct to the calcining operation, whereas all forms of kilns hitherto used do not allow of this. The slurry or raw meal in the old process has to be brought into the shape of lumps or bricks before it can be charged into the kilns. It is, therefore, necessary to mention here the different ways in which this can be done.

Burning Cement in Brick Form. Mention has already been made of the various processes of plastic brickmaking by mixing slurry and raw meal in different forms. Plastic bricks can also be made from raw meal by simply adding sufficient water to bring it to a suitable consistency for treating in a pug mill and brick machine. This will amount to 20 to 25 per cent., according to the nature of the raw materials.

The resulting plastic bricks must be dried by one of the methods already mentioned, such as tunnel dryers.

Bricks can also be made by adding only a small amount of water—say 5 to 15 per cent.—according to the nature of the raw materials, and subjecting this mixture to a very heavy pressure in so-called *dry presses*, of which a number of forms are in common use—such as toggle-joint presses, hydraulic presses, and hammer presses. In BRICKMAKING [page 1278] we have described both Johnson's and Whittaker's toggle-joint presses. In the hammer press the moist raw meal is pressed into brick-shape by heavy falling weights. The resulting dry-pressed bricks can be either dried, or else charged into the kiln in the semi-dry state. The choice of method depends on the kiln used.

Another way of making bricks which must be mentioned here, as it is frequently used in those English cement works where the raw material is blue lias lime, consists in adding a considerable quantity of water to the raw meal obtained in the dry process and pugging this in a pug mill, so as to form a semi-fluid paste, which is spread on drying floors. It is cut into squares in a half-dried condition, which, when dry, can be loosened from the floor and form bricks for charging direct into the kilns.

How to Dry Slurry. To get slurry to the right consistency for the kilns all that is necessary is to spread it in layers of suitable thickness on drying floors, and, after drying, break it up into lumps, which can be charged into the kiln.

In some places the slurry is cut into squares before it becomes quite dry; this is the method adopted in those works using blue lias lime.

General Remarks about Kilns. The temperature to which the raw materials must be subjected in order to bring about the necessary chemical changes is a very high one, but does not vary very much. To measure these high temperatures with any degree of accuracy is a difficult and uncertain operation, but it is generally assumed that the temperature in a cement kiln is about 1,500° to 1,600° C. On the other hand, the process is practically instantaneous—that is to say, as soon as the necessary temperature is obtained, the chemical changes take place at once, and the process is finished. The carbonic acid gas contained in the raw materials will have been driven out gradually before this high temperature is reached.

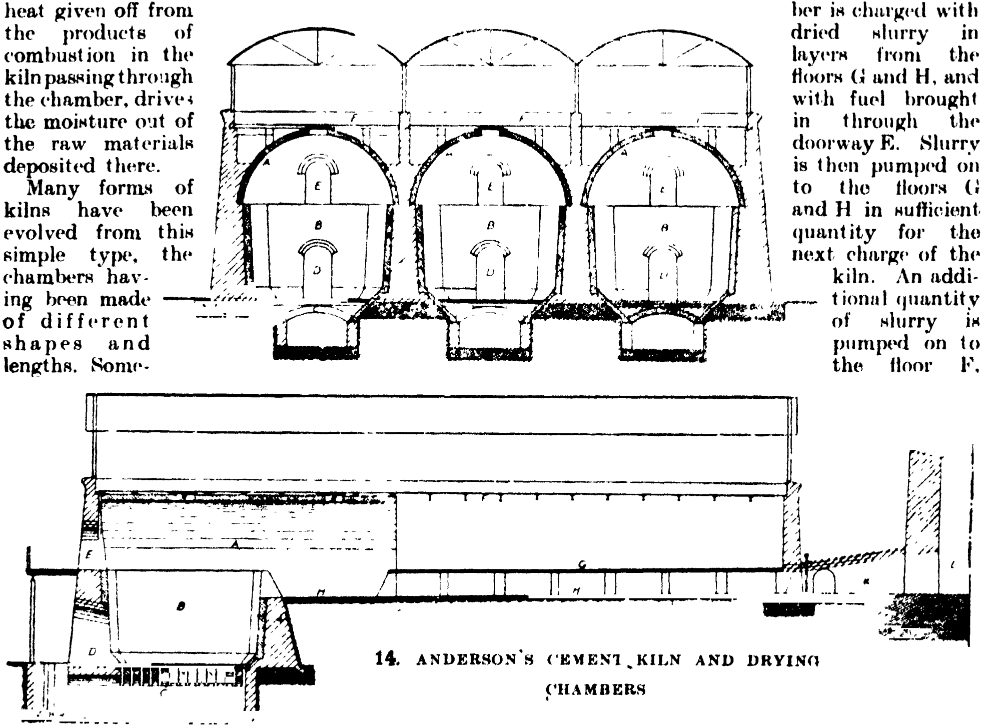
A great number of kilns of very varying type and construction have been used. They fall naturally into two main divisions, the *periodical* and the *continuous* kilns. The former are charged with the fuel and raw material, fired and allowed to burn out completely, and to cool down before they are emptied. This process is always repeated in the same manner. The continuous kilns, when in full fire are continuously emptied and re-charged by gradually discharging clinker at one end, and reloading with fuel and raw material at the other. Compare similar classes of kilns used for lime burning [page 1456].

The Bottle Kiln. This is the oldest type of kiln, and consists of a round or square chamber built of bricks, and lined inside with fire bricks. A continuation of the upper part in much thinner brickwork forms a chimney. Above the top of the kiln, at the base of the chimney, are situated one or more "loading" eyes, that is to say, openings in the brickwork for the admission of the charge. The chamber or bowl of the kiln at the bottom is provided with a grating, either of iron or of perforated brickwork, and underneath are the "draw-eyes" for removal of the clinker. The kiln, when emptied, is charged first with faggots or shavings, and above this with a layer of coke. On top of these the kiln is filled up with alternate layers of raw material and coke. When the loading is finished, the kiln is fired from below and allowed to burn out and cool. This process, as a rule, takes about five days, more or less, according to the size of the kiln. The capacity of a kiln varies from 10 or 15 tons up to 50 tons of finished clinker.

It may be here stated that bottle kilns have also been built of much larger dimensions for continuous burning; but we shall consider them later on.

The Chamber Kiln. The invention of this type of kiln is generally atrributed to J. C. Johnson, the first to manufacture Portland cement on a large scale, and is known as the Johnson chamber kiln. As a rule, it is used in connection with the wet process, but, in a few instances, for the dry process also. In either case, it consists in the addition of a long horizontal chamber flat on the bottom, with an arched roof, leading from the burning chamber or bowl of the kiln to a chimney or flue. The object of this chamber is to utilise the waste heat leaving the burning chamber to dry the charge of materials for the next burning. For this purpose, sufficient slurry for one charge is pumped up on to the flat floor of the drying chamber, or a corresponding quantity of raw meal bricks stacked in the chamber, so that the heat given off from the products of combustion in the kiln passing through the chamber, drives the moisture out of the raw materials deposited there.

Many forms of kilns have been evolved from this simple type, the chambers having been made of different shapes and lengths. Sometimes several chambers are arranged beside or above one another, in other forms both the arches have been substituted partly or entirely by floors constructed of iron plates.



14. ANDERSON'S CEMENT KILN AND DRYING CHAMBERS

As an example, we give in **14** an illustration which at the same time shows the Anderson patent drying chambers.

Old Kilns brought up to Date. We are dealing here with old chamber kilns which have been altered to improve the drying chambers so as to increase the drying capacity. It will be seen that the arches A, which before the alteration extended right away through the whole length of the kiln, have been taken down, except over and just beyond the burning chamber of the kiln B. This burning chamber is usually lined with firebricks, and has a firebrick grating (C), supported by an arch at the bottom. Access to the lower part of the burning chamber is gained through a doorway (D), which, during the burning, is closed by a temporary brick wall. This doorway also serves as a draw-eye for removing the clinker when the kiln is burnt off. Another door (E), connects the top of the burning chamber with the gangway outside, through which the fuel is brought into the kiln. The chamber is covered over by a floor (F) of wrought-iron joists supporting cast-iron plates extending throughout the whole length of the chamber, including that portion which is arched over. An intermediate floor (G), consisting of cast-iron plates resting on longitudinal girders resting again on brick piers is arranged a little way over the bottom of the chamber H.

Charging the Kiln. The burning chamber is charged with dried slurry in layers from the floors G and H, and with fuel brought in through the doorway E. Slurry is then pumped on to the floors G and H in sufficient quantity for the next charge of the kiln. An additional quantity of slurry is pumped on to the floor F, and this slurry, after drying, can be burnt in separate kilns, as, for instance, in Schneider kilns.

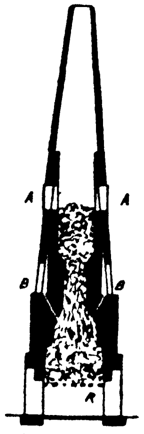
When the charging of the burning chamber and drying floors is completed, the kiln is fired. The waste heat arising from the burning clinker has room to expand freely up under the arches A and the floor F. The products of combustion are drawn off by the chimney stack L, through the flue formed between the two floors G and H, and a continuation of this in the shape of an arched flue (K). The draught is regulated by the damper I.

The outside drying floors F, are covered over by suitable roofing to keep the rain away from the slurry.

When the kiln is burnt off, some of the plates in the floor F are lifted and left open to get the inside of the kiln cooled as quickly as possible. For this purpose a couple of openings (M), in the arches, are also made, and these openings are provided with removable firebrick covers.

We have gone into this subject because it illustrates an easy means by which cement works having the old-fashioned chamber kilns can obtain more economical results with the assistance of one of the modern continuous kilns working with dried raw material.

It is possible, with the help of improved drying chambers, to let the old-fashioned chamber kiln not only dry sufficient material for its own use, but a very considerable surplus, which can then be burnt very cheaply in the more modern continuous kiln. In this way we may effect a saving on the whole output, which in several cases has been shown to amount to 2s. per ton.



15. THE AALBORG KILN

Continuous Kilns. All these kilns may be said to consist of a long channel or a series of burning chambers forming together a long channel. This channel can be vertical or horizontal; it can be built in the form of a straight line, the two ends being wide apart, or it can be bent so that the two ends meet and form one continuous channel.

The Hoffmann Kiln. The Hoffmann kiln is an illustration of this latter principle. A form of this kiln has already been described in BRICKMAKING [page 1283]. The burning channel consists of two straight tunnels side by side, and united at both ends; a number of doorways lead through the outside brickwork, and give access to the burning channel for charging the kiln with raw bricks and for removal of the clinker. The channel is arched over, and, as a rule, deflecting arches are inserted between each pair of doorways, dividing up the burning channel into several chambers. In the process of burning, the chambers in front of the fire are separated from each other by a cross partition formed of stout brown-paper pasted on. The fire progresses from chamber to chamber, and travels round the channel continuously. A certain number of chambers behind the fire are always cooling, while others in front of the fire are drying. The drying is effected by leading the products of combustion from the chambers under fire through those where the drying is in progress on the way to the chimney, which is situated at one end, and is connected with all the chambers by a main flue running round in the brickwork just outside the burning channel. The chambers are also connected with each other through a flue in the centre, so that the heat can be led from any one chamber into any other, and then away to the chimney.

It will be evident that on the opposite side of the kiln to where the firing is in progress, the chambers will be coolest. The clinker is drawn out, and raw bricks stacked in this coolest chamber.

The Hoffmann kiln has been used to a very considerable extent in the dry process works on the Continent, but has hardly ever been used in connection with the wet process, and has never found much favour in England for cement burning.

Continuous Vertical Kilns. The bottle kiln has already been mentioned above; very large bottle kilns are fired continuously. When the kiln is loaded and fired in the usual manner, and the fire has reached a certain level somewhere near the top, clinker is drawn out at the bottom, and after the charge has "set," fresh layers of coke and raw material are charged on to the top of the old charge. In this way the process works continuously. Several modifications of this system have been largely employed, and among them the use of the Schneider kiln has found great favour in England in connection with chamber kilns with improved chambers, which are able to dry a considerable surplus of slurry, besides what they themselves require.

As already mentioned above, the usual drawback to the continuous bottle kiln is the difficulty in obtaining the regular setting of the kiln—that is to say, the regular sliding action of the charge downwards; the clinker tends to bake on to the firebrick lining of the kiln, and thus prevents the setting. When this happens, the charge will hang on one side, and the setting becomes irregular, interfering with the systematic charging in of layers on to the top. Under such circumstances, a great deal of half-burnt clinker is generally formed, and the burning is unsatisfactory in every way. In the Schneider kiln this is prevented by a special loading arrangement allowing the firebrick lining to be separated from the charge, or rather from the fuel, protecting the firebrick lining with a layer of raw material of such thickness that it will only just be calcined without any danger of its baking on to the sides of the fire bricks.

Continuous and Periodical Kilns Compared. The working of a continuous kiln of this type as compared to the working of th ordinary chamber kiln shows a very grea improvement in output and cost of production Taking an average sized chamber kiln, with a output of 30 to 40 tons for each burning (whic takes about five days), the kiln will only produ about 40 to 50 tons per week. The Schneid kiln with dry raw materials will produce fro 80 to 100 tons, or just twice the quantity, an the fuel consumption which in the chamber kil averages 8 cwt. of coke per ton of clinker burn will in the Schneider kiln be less than 4 cwt However, it is only fair that we should rememb that the chamber kiln effects the drying not only of its own slurry, but also of that burnt in the Schneider kiln, and it does not cost anything extra to have this surplus dried by the chamber kiln. Four chamber kilns of the size above mentioned, with properly arranged drying chambers, will be capable of drying sufficient slurry to keep one Schneider kiln going, and their united capacity will be 50 per cent. more than the capacity of the original kilns.

A Modern Vertical Kiln. Another form of vertical continuous bottle kiln is the Aalborg kiln which we owe to Shœfer and Smidth. An illustration of this kiln will be found in **15**. The raw materials, either dried slurry or bricks, must be quite dry before being charged into the pre-heater through the charging doors A. All the fuel is charged into the centre of the kiln through a number of shoots (BB), built into the firebrick lining of the kiln half-way down between A and the grating R, and the burning takes place mostly in the conical-shaped burning chamber, where these shoots enter the kiln. In the chamber below, the clinker cools and the charge is gradually heated in the narrow neck and pre-heater above by the waste heat from the burning. The economy in fuel in a kiln of this construction has been brought to a maximum. The consumption of coal on an average is rather less than 3 cwt. per ton of cement produced, and common small gas coal can be used as fuel instead of coke.

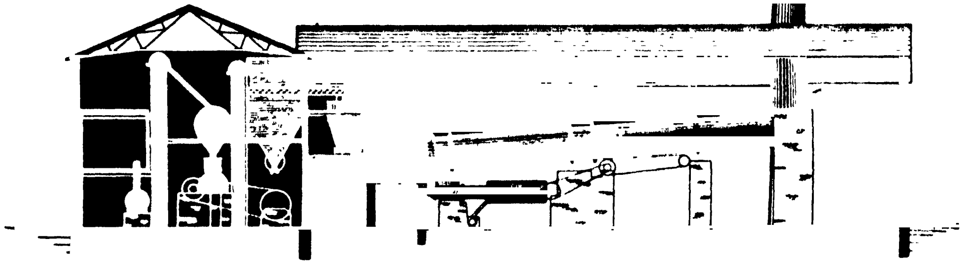
On the other hand, the burning of these kilns requires a considerable amount of skill.

The kiln has found much favour in America and on the Continent, and also in our Colonies, but not much in England itself.

The Latest Type—the Rotary Kiln. In all the kilns we have so far mentioned it will be seen that the raw materials—whether made on the wet or on the dry process—must be loaded into the kiln in the form of bricks or lumps. None of these kilns has been adapted for receiving the raw materials in the shape of a dry powder or a wet slurry, though some of them have been arranged to utilise the waste heat from one burning to dry the necessary charge for the next. Even in these cases, however, the material has to be handled after being dried.

The idea of constructing a furnace which would receive the material either as a dry powder or as wet slurry without further handling, and convert it into clinker in one operation, is a very tempting one. This is what the rotary kiln actually accomplishes.

Original Rotary Kilns. The history of its discovery and development need not detain us long. The first records are to be found in the patent registers as far back as 1877, when Thomas Russel Crampton, who had in the preceding year patented a revolving furnace for roasting ores, extended the application of his invention to cement. His kiln does not seem, however, to have been heard of since then, and in 1885 Frederick Ransome patented practically the same thing, but in a rather better form, and several kilns were built and worked. They were all abandoned before very long, as the coal consumption was found to be extravagantly high, probably because the kilns were much too small and could not utilise the fuel properly.



16. GENERAL PRINCIPLE OF A ROTARY KILN

The principle of all continuous kilns is well illustrated in the Aalborg. It consists in utilising the waste heat in the kiln itself. The actual burning takes place in the middle, and this part of the kiln is supplied with hot air which has passed over the cooling clinker underneath, while the hot gases from the burning clinker passing up give a preliminary heating to the raw material above in the upper part of the kiln before it reaches the intensely-heated middle portion.

As the burning of the fuel takes place with access of large quantities of very hot air, the burning is very complete, and the fuel is utilised to the utmost. At the same time practically no waste heat leaves the kiln.

The next we hear of the rotary kiln is in the United States, where kilns of a practical size—60 ft. long and 5 ft. in diameter—were introduced.

Originally they were intended for burning cement by means of mineral oil, but the application of the kiln was soon extended, and it was used both for wet and dry material, and was fired by coal dust or natural gas as well as oil. The use of coal dates back only to about the year 1897, as before this kilns using liquid fuel only were worked in America.

Principle of the Rotary Kiln. The principle of the rotary kiln is illustrated in **16**, **17**, **18**, and **19**, and is extremely simple. The kiln consists merely of a long, straight cylinder, which is made to revolve slowly by means of live rings on roller bearings and a suitable driving gear. The kiln is not quite horizontal, but erected with a slight incline, so that the material moves slowly downwards actuated by the force of gravity.

At the upper end the cylinder enters into a brick-built chamber, and on this, or on another brick-built chamber connected with the first, a chimney is placed to carry away the products of combustion.

The lower end of the kiln is closed either by a fixed wall or a movable hood clearly seen in **17**, with an opening at the bottom, through which the clinker falls out. The cylinder is lined entirely or partly with firebricks in order to protect the iron shell from the excessive heat and wear arising out of the quantity of hot clinker moving down it, and also to keep the heat better in the kiln by preventing too much radiation through the shell.

The speed of rotation varies somewhat, but it is rarely more than one revolution per minute, and usually less. The dimensions, which originally were at most 60 ft. in length by 5 ft. in diameter, have gradually been increased and are now commonly 120 ft. in length and 6 or 7 ft. in diameter. At Edison's Cement Works in Stewartsville, U.S.A., cast-iron kilns, made of pipes joined together by flanges have been made 150 ft. long and 9 ft. in diameter, and these, are, so far, the biggest kilns that have ever been constructed.

17. AN UP-TO-DATE ROTARY KILN, SHOWING AIR BLAST AND COAL DUST SUPPLY PIPES

Clinker Coolers and Utilisation of Waste Heat. In connection with the lower end of the kiln a clinker cooler is commonly used. This is not absolutely necessary, and in many American works the clinker simply drops on to the floor or into a steel wheelbarrow and is carried outside and spread on the ground to cool. In other American works the hot clinker as it falls out of the kiln is elevated by a strong chain-bucket elevator to the top of a cylindrical cooling tower. This tower is sometimes provided with artificial draught to cool the clinker, which then falls out at the foot of the tower, and is thence taken away to the mill.

In modern practice, however, a revolving clinker cooler is generally used, although the type of machine is subject to considerable variation.

The clinker cooler is seen under the kiln in **17**.

In the Hurry & Seaman kilns the rotary kilns themselves are laid in pairs, each pair having three coolers so arranged that two of the coolers take the clinker from the two kilns and bring it together into the third cooler, whence it is finally discharged quite cold. These coolers lead away from the kiln, so that the material from start to finish travels in the same direction.

In most of the other systems, however, the coolers are built under the kilns, so that the material in the cooler travels in the opposite direction to that in the kiln.

Smidth's cooler, seen under the rotary kiln [**16**], consists of two cylinders, one inside the other, and the material travels first in one direction inside one, the inner one, and then in the opposite direction outside it but inside the outer one. The object of this is to heat the air, which by natural draught or by the assistance of a fan passes through the cooler. This air current cools the clinker and the air is made as hot as possible when it leaves the cooler to enter the kiln. The combustion of the fuel will be greatly assisted by hot air, the hotter the better.

The revolving cooler is constructed of iron plates and fitted with running and driving gear of the same nature as that used for the kiln itself.

Firing the Kilns. In some places in America natural gas has been used, and in very few cases water gas or producer gas. In such cases the firing device is very simple, consisting of a gas pipe with the necessary means for regulating the jet.

Oil has been and is used to a large extent, especially in the United States, where in many parts it is extremely cheap.

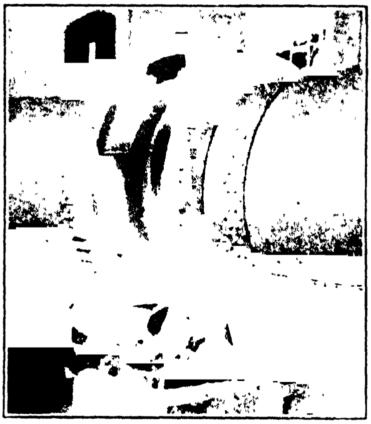
The oil flows from a tank under a certain pressure, and passes out from a special injector or nozzle. It is thus reduced to a form of spray, sometimes assisted by steam jets placed underneath the oil jets, or connected directly with them.

By far the most general way of firing the kiln, however, is by means of powdered coal.

To grind the coal sufficiently fine it is, as a rule, necessary to dry it first, and for this purpose we naturally utilise some of the waste heat from the kiln. We can arrange the plant to dry the coal by bringing it directly into contact with the lower hot end of the kiln itself, either by partitioning off the brickwork, a hopper-shaped room through which the kiln passes, or by

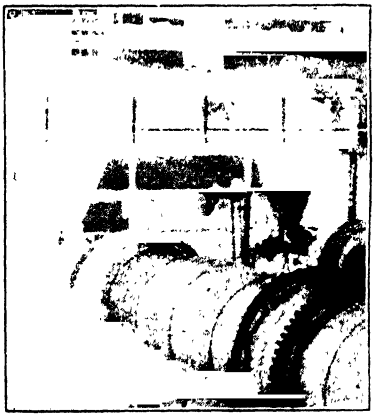
surrounding the kiln with a mantle and passing the coal through the room between this mantle and the shell of the kiln.

Another way to dry the coal, which will be mentioned later on in the description of actual rotary kiln plants, consists in passing the coal through a drying drum heated by means of the hot air from the clinker cooler on its way to the kiln



18. MODERN ROTARY KILN, SHOWING ROTARY MECHANISM

Coal Grinding. Grinding coal is a simple matter, and several classes of grinding machines are found suitable. It is only a question of working cost and repairs incurred in obtaining a product of the requisite degree of fineness. The coal-grinding machinery is seen in **16** in the building adjoining the kiln house. Ball and tube mills, or a combination of the two, will prove the most economical. The coal dust is delivered from the drying and grinding plant into a hopper with an extracting worm, where a sufficient quantity for several hours' working is always stored, so as to avoid the danger of stopping the kiln in case of a slight mishap in the coal mill. Two hoppers may be seen at the far end of the kiln [**19**]. From the bottom of this hopper the coal dust is extracted by a worm provided with an appliance for regulating accurately the quantity of coal dust fed into the kiln. From this worm it is dropped into a nozzle, through which a strong current of air from a blast fan is driven. The coal dust mixes with the air, and is carried along with it to the centre of the lower end of the kiln.



19. MODERN ROTARY KILN FROM FURTHER END, SHOWING COAL HOPPERS

The Inlet for the Raw Material. This is extremely simple in construction, the dry meal being fed from a hopper by an adjustable feed arrangement, through a shoot, and direct into the kiln. Sometimes a small quantity of water is added to it in a mixing and moistening machine before feeding into the kiln, to prevent the fine flour from being carried away by the draught to the chimney.

If the raw material be in the form of slurry it is fed into the kiln through a pipe, means being provided for a constant pressure, or head, of slurry, and the inlet pipe to the kiln being provided with a valve for regulating or stopping the flow.

Output by the Rotary Kiln. The results obtained by the rotary kiln are very different in several respects from those obtained by any other system of kiln. The clinker is much more regularly burnt, and, as a rule, of more regular shape. It leaves the kiln in the form of small round lumps, sometimes conglomerated into masses, and rarely exceeding the size of a small egg, whereas the clinker formed in other kilns consists of large vitreous and spongy lumps. The rotary kiln clinker is much harder to grind than the ordinary clinker.

The output from one rotary kiln of the ordinary size—say, 100 ft. long and 7 ft. in diameter—is about 50-60 tons per day when burning raw meal, and 35-40 tons when burning slurry.

The coal consumption is not so low as with some of the more economical continuous shaft kilns. With raw meal it may be said to vary between 4½ and 5½ cwt. per ton of clinker produced; and with slurry, between 5 and 6 cwt., according to the quality of the coal and the nature of the raw materials. It must, however, be remembered that the fuel used is coal, whereas, with very few exceptions, coke is required in the other systems of kilns. This is very often much more expensive than coal.

In **17** the firing end is the near end. The narrow pipe shown is the coal dust feed pipe. The large one is the hot air feed pipe. The end of the cylinder is formed of a movable hood, which can be taken away for cleaning purposes. The lever handles seen in the front are for regulating the feed of raw material at the other end of the kiln. The circular rack about half-way down the kiln is part of the machinery which causes the kiln to revolve. This is seen better in the next illustration [**18**]. Underneath the kiln the cylindrical clinker cooler may be seen.

Driving Gear. Fig. **18** shows very clearly the driving gear. The kiln rests on friction rollers at the middle and two ends. The middle roller is seen in the illustration as a polished circular steel hoop, resting on steel rollers and lying next to the circular rack which drives the kiln round. Note the angle irons and method of fastening the rack to the body of the kiln.

The illustration [**19**] shows two rotary kilns lying side by side, and looking towards the firing end. Here each kiln is provided with a small hopper, containing finely powdered coal or coal dust for firing. These small hoppers represent the only store of coal dust. In some of the American plant large stores were built for the powdered coal, and many fatal accidents occurred, owing to the liability of powdered coal to fire and even explode. In a single accident caused in this way, in an American works, twelve men lost their lives.

The Rotary Kiln Saves Labour. The labour in the rotary kiln is naturally reduced to a minimum. There is practically no actual labour required, but there must, of course, be a burner to take charge of the kiln. He regulates the feeds of raw material and fuel, and looks after the kiln in a general sort of way. As a rule, each kiln has a burner who is responsible for its working, but where labour is very expensive it is quite possible for one man to look after two or even three kilns. In the coal drying and grinding department there must be a man to handle the coal as it comes into the mill, and, of course, there must be an engineer to look after the machinery generally.

It will, however, be seen that the rotary kiln is an efficient labour-saving contrivance, especially when it is remembered that the conversion of raw materials into bricks or lumps is entirely avoided.

Crushing and Grinding Cement. Until comparatively few years ago, millstones were commonly used for finishing cement clinker, after it had passed a stone crusher or crushing rolls. With the increasing demand for finer grinding, however, millstones have proved too expensive, not only in respect to the power required to drive them, but also in upkeep.

The old specification of fineness was such that 10 per cent. residue was allowed on a mesh No. 50 containing 2,500 holes per square inch. Nowadays the specifications are far more stringent, as will be seen later when we consider the testing of cement.

To grind to such a fineness with millstones would be quite impracticable; with the increasing fineness the stones must be pressed tighter together; the output from each pair of stones will consequently fall quickly, while the power consumed at the same time rises very rapidly. Besides this, the stones must be dressed much more frequently, and the expense involved becomes excessive.

Merits of Mills. For a long time ball mills were used to a considerable extent as finishing grinders, but with the demand for increasing fineness in grinding, the gauze through which the ball mill discharges the finished product had to be made so fine that the cost of repair on the delicate screens ran very high.

The introduction of the tube mill, and the division of the grinding into a preliminary coarse grinding, and a finishing fine grinding effected by this machine, made the fine grinding an easy and inexpensive matter.

As these machines have been described under the dry grinding of the raw materials it is not necessary further to enlarge on the matter at this stage.

The grinding of cement differs from that of the raw materials only in so far as the cement is a much harder substance, although this in itself does not make much difference in the grinding operation. The hardness of the clinker varies considerably, and the output which can be obtained by mills of a certain size is, therefore, very variable. As a rule the clinker burnt in ordinary bottle kilns, either periodical or continuous, is so much softer than that burnt in the rotary kiln, that when a set of machines can reduce six tons per hour of an average bottle kiln clinker, the same machines will sometimes treat only four tons of a hard rotary clinker when grinding to the same fineness.

A typical arrangement of a modern cement mill, with improved ball mills or kominors, and tube mills, will be found in the description of a dry process cement works, with which we shall continue this course.

Continued

COOKERY
continued from page 1532

COOKERY RECIPES

Ingredients for, and Methods of Preparing and Cooking, various kinds of Soups and Meats

SOUPS

Tomato Soup

INGREDIENTS. Two pounds of tomatoes, one ounce of butter, two ounces of lean bacon, one ounce of sago or crushed tapioca, one carrot and one onion, one stick of celery, a bunch of parsley and herbs, a quart of stock, salt and pepper.

Method. Cut the bacon in small pieces, and fry it for a few minutes in the butter. Wash and prepare the vegetables, cut them up small, and fry them for about five minutes with the bacon and butter. Next slice the tomatoes, add them, and the herbs and stock. Put the lid on the pan, and boil the contents till tender. Then rub the soup through a sieve. Rinse out the pan, put back the soup and let it boil, then shake in the sago, and let it boil till the sago is clear. Season it nicely with salt, pepper, and castor sugar. Serve with it some fried bread.

Artichoke Soup

INGREDIENTS. Two pounds of Jerusalem artichokes, two ounces of butter, one small onion, two eggs, a little celery, one pint of white stock or milk-and-water, half a pint of cream, half a teaspoonful of chopped tarragon, salt and pepper

Method. Wash, peel, and trim the artichokes. Melt the butter in a steel or enamelled pan, put in the artichokes and the onion and celery cut in slices. Cook these carefully for six or eight minutes, taking care they do not get at all brown. Then add the stock ; put the lid on the pan and let the contents cook till they are tender ; then rub all through a wire sieve. Put it back in the pan. Beat up the yolks of two eggs, and strain them into the cream ; then add it gradually to the soup. Stir it over the fire until it is quite hot, and the eggs cooked ; but do not let it boil, or the eggs will curdle. See that it is nicely seasoned, and, just at the last, sprinkle in the chopped tarragon. This soup should be about the thickness of good cream. If it is too thick, add more milk. All milk used for this soup should first be boiled, otherwise the soup will not be a good colour.

Potatoes may be used in the same way to make Potato Soup, in which case the tarragon should be omitted, and, if liked, the cream. Add one ounce of crushed tapioca, and cook it till it is clear.

Mulligatawny Soup

INGREDIENTS. One pound of mutton, one ounce of butter or clarified fat, two turnips, carrots, onions and apples, one tablespoonful of curry-powder, a little lemon-juice, two quarts of water, two ounces of flour.

Method. Peel and slice the vegetables and apples. Melt the butter in a saucepan, then add the vegetables and apples, and fry them all for a few minutes. Put in about one pound of lean mutton, cut in small pieces. Put the flour in a basin, mix it in enough cold water to make it into a smooth batter ; and when the contents of the saucepan are boiling, pour in this batter and stir it for a few minutes, to prevent it from getting lumpy. Then put the lid on the pan, and let it simmer gently for two hours. Next rub it all through a sieve—if one is available ; otherwise, mash up all the vegetables as finely as possible. Pour it back into the saucepan, and let it come to the boil. Season it with salt to taste, serve it in a hot tureen, and hand with it some nicely boiled rice.

Pea Soup

INGREDIENTS. Half a pint of split peas, one ounce of dripping or butter, one large onion, a carrot and a turnip, half a head of celery, a small bunch of parsley, two quarts of water, stock or pot-liquor, a raw ham-bone or some trimmings of bacon, salt and pepper.

Method. Soak the peas over night. Drain off the water from them. Melt the dripping or butter in a saucepan. When it is hot, add to it the peas, onion, turnip, carrot, and the celery, all thinly sliced. Stir these over the fire in the dripping for five minutes. Next put in the parsley, the water, stock, or pot-liquor (liquor in which meat has been boiled), the ham-bone, or some trimmings of raw bacon. Cook gently for about two hours and a half, or until the peas are quite soft. Then rub all the through a wire sieve. Reboil it, well with salt and pepper, and serve dried, finely-powdered mint with it.

Lentils may be treated in the same way to make Lentil Soup.

Clear Soup

INGREDIENTS. For the stock—Three pounds of shin of beef, three quarts of cold water, one carrot, one turnip, one onion, half a head of celery, a bunch of parsley and herbs, two tomatoes, a blade of mace, four peppercorns, any scraps of chicken, ham or poultry. To clarify the stock—Half a pound of lean beef to each two quarts of stock, one carrot, one onion, half a large turnip, three allspice, two cloves, the whites of two eggs.

Method. Remove all fat from the shin of beef, and cut the meat into inch squares. Break up the bones and take out the marrow. Put the meat, bones, and half a teaspoonful of salt into a large saucepan with the water ; bring it slowly to the boil, then skim it well. Wash and prepare the vegetables, cut them in small squares, then add the herbs, peppercorns, mace, and the trimmings to the meat. Put the lid on the pan, and boil the stock steadily for four hours, keeping it well skimmed. Then strain it through a glass cloth, or a fine hair sieve, and leave it till cold. Carefully remove all fat, and wipe the surface over with a cloth dipped in boiling water ; measure the soup, and put it into a clean pan. Allow lean beef in the given proportion. Either scrape it finely or pass it twice through a mincing-machine. Put the meat into the soup, add to it the carrot, onion, turnip, and spice, after having carefully washed the vegetables, and put the cloves in the onion. Let the pan stand at the side of the stove for twenty minutes, then ladle the soup gently out of the pan into a clean cloth, which has been tied over the legs of a chair, turned upside down on a table, with a basin placed under the cloth. The soup should run through the cloth quite clear ; if not, put it back in the pan with the minced beef and the stiffly-whisked whites of two eggs. Stir it over the fire for a few minutes, pour it back into the cloth, and it will run out clear—that is, unless the cloth or basin be greasy. The Clear Soup is now ready, and may be served plain or with some garnish, such as shreds of cooked vegetables, in which case it would be Julienne Soup—the soup or "consommé" taking its name from the garnish.

Pot-Au-Feu

Ingredients. One and a half pounds of topside of beef, one cabbage, one large carrot, two onions, two leeks, one teaspoonful of parsley, one turnip, two tablespoonfuls of sago, cold water, salt and pepper.

Method. Wipe the meat. Tie it in shape with string. Put it in a large pan with cold water to cover. Add half a teaspoonful of salt. Bring to the boil and skim it. Allow it to simmer gently while the vegetables are prepared. Trim and cut the cabbage in halves. Lay it in cold, salted water. Wash, scrape, and quarter the carrot. Wash, peel, and quarter the turnip. Peel and quarter the onions. Cut off all but two or three inches of the green top of the leeks. Wash each well, and halve them lengthways. Tie the cabbage together with tape. Put in all the vegetables. Cook till they are tender ; those that are cooked first must be lifted out and kept hot. The pot-au-feu is then ready. Lift the meat on to a clean hot dish. Arrange the vegetables round it. The cabbage must be untied, and can be served separately if liked. Strain the stock into a clean pan. When it boils again, shake in the sago and stir till it is clear. Add the chopped parsley. Season, and serve this broth in a hot tureen.

MEAT

Roast Leg of Mutton

Ingredients. A well-hung leg of mutton, an ounce of dripping.

Method. Wipe the outside of the joint quickly over with a cloth wrung out in boiling water. Chop off the shank-bone all but about two inches. Next weigh the joint—this is necessary, as you must know the weight before you can calculate how long it will take to cook. Allow fifteen minutes for each pound it weighs, and fifteen minutes over—thus a joint weighing nine pounds would take two and a half hours to cook. Either put the joint before a brisk fire, or in a hot oven, for the first ten minutes ; then move it to a cooler part. Keep it well basted—it should be basted every ten minutes—to prevent the outside of the joint getting hard. When done, the meat should be a nice brown, and should feel firm when pressed. Lift it on to a hot dish, and make the gravy. First carefully pour off all fat from the tin, and pour into the tin three-quarters of a pint of boiling water or stock ; stir this over the fire, scraping the tin well to get off all the gravy and brown pieces which were left in the tin. Stir it over the fire till it boils, season it carefully with salt and pepper, and strain it round, but on no account over, the joint. All joints should be treated this way ; but should it be a piece of solid meat with no bone in it, it is sometimes well to allow twenty minutes for each pound. Pork should be allowed twenty minutes.

Boiled Leg of Mutton

Ingredients. A leg of mutton weighing about seven pounds, three carrots, three turnips.

Method. Wipe the joint over with a cloth dipped in hot water, then weigh it and allow fifteen minutes to every pound. Have ready a large pan of boiling water, put a tablespoonful of salt in it, and then the joint. Let it boil for five minutes, then skim it and put in the vegetables. Draw the pan to the side of the stove, and let it simmer gently until the joint is done. A joint weighing seven pounds will take one hour and three-quarters. Put the joint on a hot dish, arrange the vegetables round, and a little of the liquor. Serve with it a tureen of caper or parsley sauce.

Salt meat should be put into warm water, brought to the boil, and then be allowed to simmer till it is done. Pork requires to be boiled twenty minutes for each pound.

Haricot Mutton

Ingredients. Two pounds of best end of neck of mutton, two carrots, two turnips, two onions, one ounce of dripping, one ounce of flour, salt and pepper, a little mushroom ketchup.

Method. Cut the neck into small neat joints, and trim off part of the fat. Wash and prepare the vegetables and cut them into neat dice. Melt the dripping in a stewpan, and, when it is very hot, put in the vegetables and fry them a light brown. Lift them on to a plate, put in the meat and fry it quickly to close up the surface of the meat and to keep the goodness inside, otherwise the gravy would be enriched at the expense of the flavour of the meat. Lift the meat on to a plate, sprinkle the flour into the pan, and fry it carefully a pale brown. This is an important point ; if the flour is not well-browned, the stew will be a bad colour. When this is done, pour into the pan one pint and a half of cold water, stir over the fire till it boils and thickens. Then season it, add the ketchup, and put back the meat and vegetables. Put the lid on the pan and let it simmer gently for two hours, occasionally skimming it. Arrange the meat in a circle round a hot dish, put the vegetables in the centre, and pour the gravy over.

Beefsteak may be treated in exactly the same manner, and is called "Stewed Steak."

Braised and Stuffed Shoulder of Mutton

Ingredients. A shoulder of mutton, four ounces of breadcrumbs, three ounces of bacon, one teaspoonful of chopped onion, one teaspoonful of chopped parsley, one teaspoonful of mixed herbs, two teaspoonfuls of chopped mushrooms, one egg, salt and pepper. For braising—A bunch of parsley and herbs, two quarts of stock, one large carrot, turnip and onion.

Method. Bone the mutton, leaving in the knuckle-bone, which should be sawn off to a neat length. If there is any difficulty about boning the joint, the butcher will do this, although it is quite easy, providing one has a sharp knife. Mix together the breadcrumbs, mushrooms, herbs, onion, and parsley. Season highly and bind them rather stiffly together with the beaten egg. Push this stuffing into the cavity made by removing the bone, and with a trussing-needle and fine string sew up the edges. Tie the joint into a neat narrow shape with tape. Well butter a deep stewpan, put in the bones that have been taken from the mutton, and the carrot, turnips, and onion cut into slices, also the bunch of herbs and parsley, which should have been previously washed. Lay the joint on the vegetables and pour on the stock; put on the lid and let the meat simmer very gently for from about one and a half to three hours. When done, place the meat on a hot dish and brush it over with a little melted glaze to brown it nicely, and serve it with brown sauce. Mint sauce should also be handed round in a tureen.

Lamb or veal may be treated in the same way. For the latter, a teaspoonful of grated lemon-rind should be added to the stuffing.

Irish Stew

INGREDIENTS. Two pounds of middle of neck of mutton, four pounds of potatoes, one pound of onions, one pint of cold water, salt and pepper.

Method. Wipe the meat with a cloth dipped in hot water. Cut off the gristle, and divide the meat into small joints. Peel and slice the onion. Put the meat, onions, and water into a saucepan, and put it on the fire; when it comes to the boil, skim it well. Scrub and peel the potatoes, and cut them in halves. Put the potatoes in a saucepan on the top of the meat, add a little seasoning of salt and pepper, and let it simmer gently for two hours. Arrange the potatoes in a ring round a hot dish, and put the meat in the centre. Pour the onion and gravy over. Should there be any gravy left, it can be put in a hot tureen.

Roast Beef

INGREDIENTS. Nine pounds of sirloin or any other good cut, one ounce of dripping, salt and pepper, a small stick of horseradish, if possible.

Method. Wipe the joint and tie it firmly in shape. Tie a piece of greased paper over the top fat, removing it the last hour. Roast the joint before the fire, or bake it in the oven for about two and a half hours. If the meat is baked, or if it be very fat, the paper need not be used. Put the extra dripping in the tin with the beef, and baste it frequently. When cooked, place the joint on a hot dish in a hot place, and pour the dripping out of the tin, carefully keeping back all brown gravy and particles. Add about half a pint of boiling water or stock to the contents of the tin; place the tin over the fire, stirring and scraping it well, in order that the particles just mentioned may flavour and colour the gravy. Strain this, after it is seasoned, and pour it round the joint, which may be garnished with little tufts of grated horseradish.

Beef Galantine

INGREDIENTS. One pound of beefsteak, half a pound of breadcrumbs, one pound of raw ham or bacon, a little mace, a small nutmeg, salt and pepper to taste, two eggs, glaze.

Method. Put the steak through a mincing-machine, and chop the ham or bacon very fine. Put all the ingredients, except the glaze, into a basin, and mix them very thoroughly. When this has been done, make it into a roll, tie it up in a pudding-cloth and boil it in the stockpot for about three hours. Untie the cloth, and re-roll the meat very tightly in it, then place it on a dish with another dish on top, on which you have put a weight. Leave it until cold, then brush the roll over with melted glaze, and decorate it with either aspic jelly or butter put on with a forcing bag.

Oxtail en Casserole

INGREDIENTS. One large oxtail, two ounces of butter or beef dripping, two ounces of lean bacon or ham (or trimmings of either could be used), one small onion, one tablespoonful of chopped mixed pickle, one tablespoonful of melted glaze, two tablespoonfuls of celery cut in dice, two tablespoonfuls of carrot cut in dice, one pint of good stock, salt and pepper, half an ounce of flour.

Method. Cut the oxtail into joints about two inches long, and put these in tepid water for about one hour. Then take them out and dry them well. Melt the butter in a pan; put in the sliced bacon and vegetables and the pieces of oxtail. Fry all a light brown. Next turn the contents of the pan into a casserole; if there is not one available, a stewing jar will do. Add the stock and pickles, cut in large pieces. Cover the casserole closely, and let the contents simmer gently for at least two and a half hours, keeping the top well skimmed. Mix the flour smoothly with a little cold water; then add it to the stew, and allow it to boil thoroughly. Lastly, add the glaze and seasoning, and serve it in the casserole. A small glass of brandy or marsala may be added.

Any meat, poultry, or game may be cooked "en casserole," either on the stove or in the oven.

Kidneys à la Maitre D'Hôtel

INGREDIENTS. Three sheep's kidneys, one teaspoonful of chopped parsley, salt and pepper, one and a half ounces of fresh butter, small rounds of bread.

Method. Split each kidney, open it, and keep it flat with a skewer. Put them into a frying-pan with the cut side down, and fry them for eight minutes. Meanwhile, work together on a plate the butter, parsley, and seasoning, making the mixture up into three neat pats. Cut the rounds of bread and fry them a light brown. Put a kidney on each; dust them with salt and pepper, put a little pat of butter on each, and serve the dish as hot as possible.

Continued

Group 24
PHYSICS
12

Continued from page 1566

HEAT OF LIQUIDS AND GASES

Expansion under Heat. The Calorimeter. Heat of Water and its Effect on Climate. Latent Heat. Evaporation

By Dr. C. W. SALEEBY

LIKE gases, liquids expand when they are heated—that is to say, nearly all liquids do so. But liquids differ very markedly among themselves in their measure of expansion, whereas we have seen that all gases expand in the same measure. Not only so, but one and the same liquid will expand at very different rates for a similar rise of temperature in different parts of the scale. Water, for instance, at 30° C. expands four times as much for a rise of temperature of one degree as it does for a similar rise at 10° C. Hence it follows that liquids are theoretically quite unsuitable for thermometers. But the reason why spirits and mercury are so constantly used is that within certain limits the expansion of these two liquids is very nearly uniform—sufficiently for ordinary purposes.

Convection Currents. If we take an ordinary liquid such as water and apply heat to a portion of it contained in a vessel, by a spirit lamp, for instance, the heated water rises, since its specific gravity is lowered, and colder water flows from above down the sides of the glass to take its place. Hence we get what are called *convection currents.* The heat is conveyed from one part of the water to another by the actual transit of the heated molecules of water. This mode of the transference of heat is called convection (from the Latin *veho,* I carry) and must be distinguished carefully from the two other ways in which heat is transferred from place to place. Even if the heat were applied to the water from above, so that the hottest water, being the lightest, remained at the top, the water at the bottom of the vessel would gradually rise in temperature. This would occur by the same process as that by which one end of a poker becomes warm when the other is held in the fire. This is the *conduction* of heat as distinguished from its *convection,* and is a very much more interesting matter, which must be studied later. The difference is obvious. In the case of the poker or the water heated from above, the molecules of iron or water do not carry the heat from one place to another, but hand it on. The Gulf Stream is the most striking instance we know of a convection current.

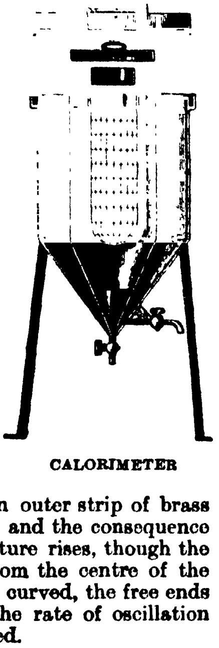
The Peculiar Behaviour of Water. By far the most remarkable facts in connection with the expansion of liquids are those concerned with the very peculiar behaviour of water, which is at its maximum density at a temperature of 4° C., and which expands as it is cooled below this point, so that ice is lighter than water just above the freezing point. We commented on this extraordinary property of water on page 798 and observed its immensely important consequences for human life, and, we might have added, for the life of the fish. But, indeed, this does not exhaust the peculiarities of water in relation to expansion by heat, for Sir James Dewar has lately shown that ice displays certain peculiarities in this respect, and that when the ice with which we are familiar is cooled below a certain point, there is formed a new sort of ice, which may be called normal ice, and the behaviour of which in relation to heat is similar to that of other bodies.

Expansion of Solids. Solids, also, like liquids and gases, expand with heat, and contract on cooling, though their changes are not so marked. Innumerable experiments may be devised to illustrate the expansion of solids. One of the best of these may be made with a brass ball which is just small enough to pass through a ring. If now the ball be heated, it will no longer pass through until it cools and so becomes small enough. The degree to which a solid expands when heated is susceptible of measurement, and it is found that, as in the case of liquids, solids differ very much among themselves in this respect. Physicists speak of *coefficients of expansion,* and these may deal with expansion in length, which is called *linear expansion,* or with expansion in volume, which is called *cubical expansion,* or with expansion of surface, *superficial expansion.* The consequences of expansion are very important, and sometimes it is of great importance to place together substances which have the same coefficient of cubical expansion. For instance, in the making of incandescent electric lamps, it is necessary to use glass which has exactly the same coefficient of expansion as platinum wire, which is employed simply because it is possible to make glass that exactly corresponds with it in this particular.

Consequences of Expansion. The consequence is that when the lamp is lit, the glass and the platinum expand together. Another illustration may be sought in dentistry. One of the absolute essentials for the successful filling of a tooth is the employment of a filling, usually a mixture of metals, which has exactly the same coefficient of expansion as the tooth itself. When this precaution is not taken, as, for instance, when the necessary details are not properly observed in preparing the filling, the tooth will soon be cracked. If, for instance, one drinks a hot liquid, the filling will expand to a greater degree than the walls of the cavity, and will burst its bonds. On the other hand, if its expansion be too small, it will not expand sufficiently, and microbes will make their way in past its sides, or it will fall out.

In various familiar operations some other consequences of expansion are observed; as, for instance, in the heating of tyres so as to fasten them on to wheels, which they grip firmly as they cool; and as in riveting, the rivet is inserted at red heat, and when it cools it shortens, so that the plates are held firmly together. Another instance is furnished by the cracking of a tumbler when very hot water is poured into it. The reader who is familiar with the test tubes used in chemistry may wonder how it is possible to boil liquids in such thin tubes when a strong tumbler would certainly crack. The explanation is, that the tubes are so thin as to expand equally throughout when heated. But in the case of the tumbler, the inner surface of the glass expands before the heat has had time to reach the outer surface by conduction, and so is apt to split its casing, just like the badly made tooth-filling.

Compensating Devices. The differences of expansion in various metals are of great use. In a good clock, for instance, the pendulum must not consist of one metal because this would expand in summer-time, lengthen the pendulum, cause it to swing more slowly, and therefore make the clock slow. In order to obviate this, there are made what are called *gridiron pendulums*, in which rods of iron and of brass alternate in such a fashion that the expansion of the one in the one direction is compensated for by that of the other in the other direction. Similarly, every good watch has a compensation balance; the balance wheel is not a complete circle but consists of two halves, each of which is just short of a semicircle. These halves consist of an outer strip of brass and an inner strip of steel, and the consequence is that, when the temperature rises, though the strips tend to move out from the centre of the wheel, they become more curved, the free ends turning inwards. Thus the rate of oscillation of the wheel is not retarded.



CALORIMETER

The Measurement of Heat. Literally, a thermometer is a heat measurer, but we have already seen that the thermometer merely measures heat level, and that only under certain very definite conditions does the thermometer serve as an index to the amount of heat in a body. In order to measure heat, we must have a unit, and the unit of heat, or thermal unit, is that amount of heat which can raise one gramme of water from 4° C. to 5° C. This amount of heat is technically known as a *calorie* (from the Latin *calor*, heat). This is the only unit of heat we need now consider, as it is now in universal use. The fact that makes it necessary to specify the temperature of the water was noted at the beginning of our discussion. It takes more heat to raise the unit mass of water through one degree, from 80° C. to 81° C., than from 4° C. to 5° C.

Specific Heat. Now, we have also seen that in the case of water and mercury we require to put far more heat into the water in order to cause a given rise of temperature than into the mercury, and this gives us a clue to the meaning of what is called specific heat. This is best defined as the number of calories or units of heat necessary to raise a unit mass of a substance through 1° C. Thus the specific heat is really a measure of the capacity for heat of any body. Now, in order to study this subject, we obviously need more apparatus than a mere thermometer, and the apparatus employed is called a *calorimeter*. This essentially consists of a box containing a thermometer and a quantity of water. This box, usually made of thin copper, is placed in other boxes and is carefully supported on props in such a way that no heat can get out of it, and the thermometer is carefully fixed in the handle of a stirrer which passes through a hole in the cover of the calorimeter. If we now place inside the calorimeter any body at a given temperature, the thermometer will readily enable us to ascertain the amount of heat which such a body has been able to impart to the water of the calorimeter—the amount of which is, of course, known.

The Specific Heat of Water. Another remarkable peculiarity of water is that it has a very much higher specific heat than any other known substance. This being so, its specific heat is taken as *one*, and the specific heat of other substances is stated proportionally. In general, the metals have low specific heats; those of brass and copper, for instance, are less than one-tenth that of water. On the other hand, the specific heat of alcohol and glycerine is more than ·6 and that of ether is more than ·5. The consequences of the high specific heat of water are almost as striking as those which follow its peculiar behaviour as regards expansion near its freezing point. In the first place the high specific heat of water means that a given quantity of water at a given temperature contains more heat than a similar quantity of any other substance, and, in cooling, such a quantity of water necessarily gives out more heat than any other substance, just as, in raising its temperature, more heat had to be put into it. Hence, for warming purposes, water is the most valuable agent. A hot bottle filled with mercury, for instance, would be quite cold in a very small fraction of the time required to cool a hot-water bottle; and it is this property of water which makes it so useful in hot-water pipes.

Water and Climate. This property of water also profoundly affects the climate, for it tends constantly towards equalising the temperature. In summer the water does not have its temperature raised so quickly as the land, its specific heat being so much higher. This means, of course, that at night heat will tend to flow to the sea from the land, the temperature of which is thus kept down. But in winter the land rapidly loses its comparatively small store of heat; the sea, however, is able to supply it from its own plentiful store, and thus the climate is made more equable, the summer milder, and the winter less cold. These are the characteristics of an insular climate such as our own, and they are of the utmost value. The relatively cool summer that depends upon the high specific heat of the water surrounding us, tends to set some poor bounds to our terrible infantile mortality, which depends mainly upon the bacterial decomposition, under the influence of heat, of milk and other food; and the relatively mild winter, due to the same cause, tends to keep down the death rate from pneumonia, bronchitis, and other diseases of the lungs. We abuse our climate, but it is one of the best in the world; for it has not only the advantages of an insular climate, due to the high specific heat of water, but is also ameliorated by that great convection current which is called the Gulf Stream, and which constantly carries to us quantities of heat from the tropics.

Though all other liquids fall far short of the specific heat of water, they have higher specific heats, as a rule, than solids; and it is also the rule that the specific heat of a substance is higher when it is liquid than when it is solid. The specific heat of ice, for instance, is only one half that of water: this being an instance of the general proposition that the specific heat increases with the temperature of a substance.

Latent Heat. Another of the most striking effects of heat is its power of changing the physical state of matter. This has already been discussed at some length in relation to the kinetic theory of gases and molecular motion. We know that there are three well-recognised states of matter and that these differ essentially in their measure of molecular motion; and we have seen also that heat and molecular motion cannot ultimately be distinguished from one another. Suppose we melt some ice at the freezing point; the temperature of the ice was 32° F., the temperature of the water formed when the ice melts is also 32° F.; what has become of the heat we employed in melting the ice? We must believe that it is represented by the more active molecular motion of the water, and this heat, or heat that was, is now called latent heat. In this particular case it is the latent heat of fusion (or melting). This may be defined as the number of thermal units required to change one unit of mass of a solid into a liquid without changing its temperature.

Determination of Latent Heat. Latent heat was first discovered by that remarkable genius, Joseph Black, who was mentioned in the first section of the course on CHEMISTRY. He determined the latent heat of water by what is called the *ice block calorimeter*. A ball of metal heated to a known temperature is inserted into a hole of a block of ice, the hole being covered with a slab of ice. The metal is gradually cooled until it reaches the freezing point, and in doing so it melts a quantity of the ice. The water thus formed is poured out and weighed. If we know the weight of the metal, and its specific heat and its temperature when it was inserted, we know the number of calories necessary to convert into liquid a quantity of ice corresponding to the weight of the water that is formed. Another method that may be employed consists in the insertion of a known quantity of ice into a calorimeter.

When we spoke of the Fahrenheit scale, we referred to the mixture of ice and salt, which provided Fahrenheit with the lowest temperature that he could obtain. Such a mixture is called a freezing mixture, and everyone who has made ices at home is familiar with it. The ice tends to melt, but in doing so it is compelled to obtain from its neighbourhood the amount of heat represented by the latent heat of water. As it melts, it dissolves the salt and thus forms brine. Now the freezing-point of brine is very much lower than that of water. Hence, such a mixture will readily freeze the mixture of milk, water, and so forth, of which ices are made.

Again, we find that water is distinguished in respect of its latent heat, which is about 79° C. That of iron is 23, of lead 5·3, and of mercury 2·8.

Temperature and Expansion. Our discussion of molecular motion in a previous section will enable us to believe that a change of volume is usually observed at the melting point, and we should rather expect that when a solid melts it should occupy more space than formerly. In the case of water, however, as also in the case of various metals, such as iron and lead, the solid occupies more space than the liquid at the freezing point. This is why cold cracks the water pipes. The water appears when the thaw comes, but that does not imply that it is the thaw which breaks the pipes; the pipes were broken with the frost, which solidified the water and caused it to expand, thus bursting the pipes; the thaw merely demonstrates the consequences.

Having observed how the question of pressure must always be correlated with that of temperature—as, for instance, in Boyle's law—we shall be prepared to believe that pressure affects the melting point; and this is so. In general, the bodies which contract when melting, melt more easily—that is to say, at a lower temperature—if pressure be applied to them. This is evidently reasonable, since the pressure tends to make them contract. Conversely, bodies which expand when they melt naturally melt with a greater difficulty under increase of pressure.

Regelation. These facts account, in the case of water, for the exceedingly important phenomenon called *regelation*. If a weighted wire be passed across a slab of ice, its pressure will cause the ice to melt, so that it gradually cuts its way through the slab, leaving, however, not an open track, since the water easily freezes again as soon as the pressure of the wire is removed. Similarly, if two slabs of ice are pressed together, and then the pressure be removed, they are found to have become continuous with one another. The pressure caused the surfaces in contact to melt, and when it was removed they froze together. It is now believed that this phenomenon explains the motion of glaciers [see Geology]. Hence, though ice is a solid, it yet moves down a glacier valley almost as if it were a viscous liquid. For the ice which is in contact with the bed of the glacier is constantly being induced by the pressure above it to melt and then freeze again in a fresh position, thus enabling the whole slowly to move on. Therefore we must regard the motion of glaciers as mainly dependent upon the influence of pressure upon the melting point of water.

Liquids and Gases. Just as the addition of heat causes solids to liquefy, so it causes liquids to evaporate or become gaseous. If we take the case of water placed in a saucer, we find that it ultimately disappears; it has evaporated. Even ice evaporates without first passing through the obviously liquid stage. The converse process we call condensation, and every child who has looked through a pane of glass on a cold day is prepared to understand that the gaseous water which has left his lungs has become liquid by contact with the cold glass. Now, questions of evaporation and condensation are determined largely by pressure as well as by heat. We have said that water, and even ice, evaporate at all temperatures. But if the air above the water were already saturated with water vapour, no more water would be evaporated. Thus the evaporation of water depends not only upon temperature, but also upon the pressure of water vapour. But this pressure varies at different temperatures, so that, here again, we have pressure and temperature correlated. Saturated water vapour increases its pressure as the temperature rises. When the temperature falls some of the vapour is condensed, and the pressure is less.

We often talk of volatile liquids, and the term may be used to imply those which are very readily evaporated at ordinary temperatures, having a large vapour pressure. Conspicuous amongst these are ether and alcohol, which have a much higher vapour pressure than that of water. Some liquids, however, cannot be evaporated at all, and so the term volatile may be applied to all the others. The two uses of the term are unfortunate.

Vapours. We must carefully distinguish between unsaturated and saturated vapours. The former are simply gases, and obey Boyle's law. Of the latter, the following law may be stated: *The saturated vapour of every liquid that forms a vapour exerts a certain pressure, differing with various liquids, at a given temperature, and this is always the maximum pressure which it can exert at that temperature.*

In the case of every gas there is a temperature which is called the *critical temperature*, and as long as it is above this point no amount of pressure will cause the gas to liquefy.

We must now also formulate the law frequently referred to in relation to the partial pressure of the carbonic acid gas and other constituents of the atmosphere. It is that *in a mixture of vapours and gases*—as, for instance, in the case of air, which always contains a quantity of water vapour—*each constituent exerts its own pressure independently of the other, provided that there is no chemical action between them.* This fact may be expressed by saying that, so far as the pressure of the water vapour is concerned, the air acts as a vacuum towards it—"one gas acts as a vacuum to another."

Evaporation and Boiling. In both these processes there is the transference of a liquid into the gaseous state; but in the case of the former, it is necessary that, for the vapour to form at the surface of the liquid, the space above it *be not saturated*; whereas, in the case of boiling, the vapour is discharged into saturated space, being formed at the temperature of saturated vapour at the pressure in the liquid. Thus we may define the boiling point of any liquid as the temperature of saturated vapour at the pressure in the liquid. Water vapour at any given pressure must have a definite temperature, and the pressure of a bubble of water vapour, formed when water boils, must at least equal the fluid pressure outside it; otherwise, plainly, it could not maintain its bubble form.

Therefore, at the ordinary atmospheric pressure, the bubble of water vapour formed in boiling water must have a temperature of 100° C. Bubbles may be formed at the bottom of the kettle, for instance, before the water reaches this temperature. Such bubbles, however, cannot rise unchanged through the liquid, but are condensed when they reach the surface. It is not until the whole of the water has reached the boiling point that the bubbles formed below can pass unchanged through the liquid, and it is not until we see this occur that we can declare the liquid to be boiling. As the heat continues to be applied, the temperature of the remaining liquid is not increased, but all the heat is used up in converting part of it into a vapour.

Boiling under Various Pressures. In the case of ordinary boiling water, the external pressure is simply that of the atmosphere, but we are now able to understand that if the atmospheric pressure be altered, the boiling point must be correspondingly altered—that is to say, the vapour of the liquid escapes when the water is at the temperature corresponding to the external pressure. If, then, we lower the external pressure, the boiling point is correspondingly lowered—that is to say, the vapour can be given off freely at a lower temperature than before. This fact provides us with a more or less accurate means of determining heights. For if we boil water on a mountain, a thermometer will indicate the new boiling point, and from the degree to which this has been lowered we can infer the lowering of the atmospheric pressure, and thus the height at which the reading is taken. A consequence of this fact is that on the tops of high mountains cooking is performed with difficulty. For instance, it is impossible to cook an egg at a height so great that the boiling point of water is below the temperature at which the white of an egg coagulates or solidifies.

Boiling under High Pressure. But, just as the pressure is lowered by ascending a mountain, so it may be raised by boiling in some sort of a vessel which does not permit the vapour to escape readily. In such a case, the external pressure is much higher than that of the atmosphere, since the partially confined steam exerts a pressure upon the surface of the liquid. We are now prepared to accept the fact that in such a case the boiling point is raised.

Latent Heat Again. When discussing the liquefaction of ice, we made the acquaintance of latent heat, and saw that in the act of converting ice at freezing point into water at the same point, much heat was employed, though there was no rise in temperature. This we called latent heat of fusion. Similarly we find that when a liquid is converted into a gas a quantity of heat is absorbed, and this we call latent heat of evaporation. It is the heat which disappears —needless to say, it is not annihilated—when liquid at the boiling point is changed into vapour at the same temperature. The heat is still there, but it cannot be perceived by the senses; it lies hidden, and hence is called latent (from Latin *lateo,* I lie hid), whereas the heat which can be perceived, or "sensed," is sometimes called *sensible heat.*

Washing without a Towel. If we wash the hands on a cold day and allow them to dry without a towel, we soon discover how cold they become—so cold that the skin is apt to be injured, and the hands become chapped. Why should the evaporation of the water from the hands cause them to become cold? The reason is evident. The latent heat of evaporation has to come from somewhere. Whenever any part of a liquid evaporates, some sensible heat must become latent. And that is the case with the hands. The additional energy of molecular motion which the water vapour possesses in virtue of its more active molecular motion is obtained by the transformation of sensible into latent heat, and the heat in our blood has to pay the penalty. The more rapid the evaporation, the greater is the reduction of temperature of the body from which it occurs.

Hence, alcohol, ether, *Eau de Cologne,* and similar substances, are used in preference to water for relieving a headache, or reducing the temperature of a hot and painful area of skin. These facts also explain the objection to wetting one's feet. As the footgear dries, the latent heat of evaporation of the water has to be obtained from somewhere, and the feet pay the penalty. But we have already seen that the rate of evaporation, or its possibility at all, is determined by the amount of vapour already present in the air. When the air is saturated, it can hold no more, and evaporation ceases. Hence, the importance of a current of air in the process of drying anything, and hence the danger of a current of air, or a draught, in causing the perspiration to evaporate too rapidly—more rapidly than its tendency to saturate the atmosphere around it would permit if the air were still—and thus to lower the temperature of the body and reduce its resistance to microbes, so that we catch cold.

Just as changes of pressure affect the boiling point, so they affect the speed of evaporation at any given temperature; and, as we should expect, evaporation is hastened by decrease of pressure, and is retarded by increase of pressure.

A Criticism of Latent Heat. In the attempt to secure accuracy of language, or, at any rate, of comprehension, we must recognise that the term *latent heat* is perhaps only a convenient fiction. Certainly, it does appear to be so if we consider the case of a given mass of the same substance at the same temperature; for instance, liquid water, and water vapour, at 212° F. The water is said to contain far more heat in the one state than in the other. What it contains, of course, is not heat at all in the ordinary sense of the word, but it is increased molecular motion, increased energy which was formerly heat energy, or sensible heat, and is now called latent heat for convenience, but is really not heat at all, any more than any other kind of energy is heat; yet, nevertheless, it was heat, and under suitable conditions can be transformed into heat again. In short, as we shall see later, heat is a form of energy, and all forms of energy are mutually convertible. That, however, is no reason why, save for mere convenience, we should apply the term *heat* to any of them except to sensible heat.

Continued

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THE REAL END OF LEARNING

The Application of Education in all the Walks of Life. Value of Observation. How to Utilise Knowledge. Influence of Education on Character

By HAROLD BEGBIE

AMONG all the noise and strife which seem to be inseparable from the public discussion of Education, it is seldom that we hear one quiet and steadfast voice proclaiming the definite and sovran end of laborious learning.

People, for the most part, are content to regard education as a weapon to be used in the battle for daily bread. The schoolboy is encouraged by his parents to stick to his books that he may pass such-and-such examination, and so provide for himself a comfortable income. The working classes look upon national schools as a means for enabling them to enter the middle-classes. The middle-classes look upon public schools and universities as means for enabling them to improve their positions and secure a pension. Everywhere this Philistine notion obtains, and narrows the view of learning. We regard the schoolmaster as the benefactor of our social circumstances; the book of wisdom is the guide to the book of pounds, shillings, and pence.

The Two Doctors. Now, it is just and right to desire an improvement in our social circumstances, and it is fair and proper to use education to this selfish end. But our worldly advantage is neither the only nor the most important destination of learning, and so to regard it is to bring about our own discomfiture.

We have only to look about the world to see how disastrously such a concept of education works in the affairs of men. Take the profession of medicine. A boy goes from school to one of the hospitals, works desperately hard at his books and in the wards, and finally passes all his examinations with honours, and is entitled to describe himself as a Doctor of Medicine. He sets up for himself in practice, continues to keep himself abreast of medical discovery, and manages to earn sufficient money for daily bread. But he is not the successful doctor of the district. The man who passed the same examinations as he passed, and perhaps with less ease and less honour, is the man of whom everybody in that district speaks with praise, the man who introduces new methods and fresh ideas, and who enjoys all the rewards and advantages of the medical profession. What is the difference between these two men? Both have been educated to figure and describe themselves as Doctors of Medicine; both have qualified in the same tests. What is the difference? The difference is this: one has learned to *apply* his education and to succeed as a doctor, and the other man has not.

There are thousands of engineers in England, but the great inventor—the man who has learned to train himself to apply his knowledge of engineering to the problems of mechanics—is as rare as a poet.

There are thousands of clergymen in England, but the great minister—the man who has learned to train himself to apply his knowledge of Christian history to the problems of the soul—is almost as rare as a blue moon.

The Rarity of Genius. The world is full of people who have passed examinations, but genius is, perhaps, even rarer than it was before the era of intellectual competition. Consider how the quiet watching of an apple's fall to the ground and the secret contemplation of a kettle's bubbling lid accomplished more for human progress than generations of book cramming and ages of competitive examinations.

In one of those remarkable novels which give witness to the troubled awakening of Russia, M. Maxim Gorki has a remarkable passage on the subject of modern education. In "The Man Who was Afraid," a successful but turbulent and unstable merchant is made to address his son in these words:

> "I wish to tell you that school-books are but a trivial matter. You need these as a carpenter needs an adze and a pointer. They are tools, but the tools cannot teach you how to make use of them. Understand? Let us see: Suppose an adze were handed to a carpenter for him to square a beam with it. It's not enough to have hands and an adze; it is also necessary for him to know how to strike the wood so as not to hit his foot instead. To you the knowledge of reading and writing is given, and you must regulate your life with it. Thus it follows that books alone are but a trifle in this matter; it is necessary to be able to take advantage of them. And it is this ability that is more cunning than any books, and yet nothing about it is written in the books. This, Foma, you must learn from Life itself. A book is a dead thing; you may take it as you please, you may tear it, break it—it will not cry out. While, should you but make a single wrong step in life, or wrongly occupy a place in it, Life will start to bawl at you in a thousand voices; it will deal you a blow, felling you to the ground."

The Mind of the Mind. In the matter of life, books indeed are but a trifle, and the cunning to take advantage of them is verily more than the books themselves. The problem with which we are now concerned is this same question, this same perplexing problem—how to acquire the cunning to use our learning to a successful end. "Nothing about it is written in the books." Richard Jefferies remarked on this same lack of teaching, and in the course of his argument employed in different fashion M. Gorki's metaphor of the tool and the carpenter. He compares the soul or the personality with the mind or the intellect of a man, and says (in "The Story of My Heart"):

> "Now the soul is the mind of the mind. It can build and construct and look beyond and penetrate space, and create. It is the keenest, the sharpest tool possessed by man. But what would be said if a carpenter about to commence a piece of work examined his tools and deliberately cast away that with the finest edge? . . . We are taught to employ our minds, and furnished with materials. The mind has its logic and exercise of geometry, and thus assisted brings a great force to the solution of problems. The soul remains untaught, and can effect little."

The question is cleared of some of its difficulties, and an excursion into this untravelled region is rendered less disheartening by providing ourselves at the outset with a practical and certain definition of the term Education.

The Perfection of the Brain. Education is in reality a means for the perfection of the human brain. It is the qualified engineer whom we train to take charge of and to oversee the delicate machinery of the brain. Or, in another way, we learn by education to operate and control this machinery, and to get out of it the finest work of which it is capable. The best educated man is not he who can compile a gradus but cannot write an interesting letter; that man is the best educated who has so intimate a control of all the functions of his brain as to be able to employ it in its several departments for the benefit of mankind and for his own highest enjoyment. Education is meant not merely to supply information—the present prevailing heresy—it is meant to develop the creative and inventive faculties of the brain, to stimulate and quicken intellectual curiosity, and to bring into action the many and harmonious functions of the soul which work together for the happiness and victory of the perfect man. In a phrase, education is intended to train the mind, "to render it elastic, subtle, and adaptable." It is a drawing-out of consciousness; not a cramming full of suffocating facts.

Training the Mind. Now, a little consideration suffices to encourage the supposition that there must be exercises for training the mind as obvious and as certain as those for increasing the muscular activity of the body. Serious thought on this subject convinces us that these exercises do exist; and we presently see those certain and definite exercises arranging themselves in order as perfect as that of the drill-ground. Indeed, it is not strictly true, as Gorki says, that "nothing about it is written in the books." Little is written about these definite and obvious exercises for training the mind, but if we study literature we find that every sage has written about them in every age, and that it is the "practical" people in charge of the machinery of education who have often left them out of their consideration, and who have more or less ignored their absolute significance.

Education and Character. The chosen end of all the exercises for training the mind which we shall deal with in this course of study is the perfection of the machinery of the mind; but the chief result of them, however applied they may be, and however unexpected that result may be, is character. The wise man will consider in all his studies that either for good or for ill he is thereby influencing and perhaps actually forming his character. Education is the fundamental problem it is because of its tremendous significance for character. To lose sight of this fact is to lose sight of life itself.

Thoreau declares his belief that the mind can be permanently damaged by attending to trivial things, and it is certain enough that miserable habits and mean studies do visit their unhappy results—either seriously or moderately—upon the mind and character of their victims. How much more, then, shall a persistent and steady course of study affect the mind and influence the character? It is, indeed, a work passing the wit of man to divorce learning from personality. When we say with Wordsworth that the boy is father to the man, what more can we mean than this, that as the boy learns in childhood so will his character emerge in manhood? Heredity may or may not play a giant's part in character, but there is no debatement as to the certain effects of learning and study—either for good or for evil.

The Great Moving Force. As a man learns, so his character emerges; by what he learns, so is his character influenced. But those who believe that "the mind of the mind" can be trained, who are persuaded that the soul should have her arithmetic and logic, and who attest their conviction that the future of education lies in this direction, go further than the loose admission that learning affects the character, and declare that right and true education can produce character, can actually create in the brain a soul in complete mastery over the body, and that it is in truth the chief weapon in the armoury of progress.

From this standpoint education opens up a field that extends far beyond the four walls of the class-room. From a local place in the affairs of men it widens till it occupies universal territory. Instead of a means for passing examinations, it becomes the central force in evolution. It is no longer the path to a pension, or the ladder from slum to suburb, but the moving force of universal governance. It is not a spoon which feeds the mouth of infancy with the sop of information; it is the weapon wherewith a man beats his way from stale usage, and wins to the clean shores of fresh truth. It does not pause at the school-room, nor cease at the gates of the university; it accompanies a man on his journey through life and brings with every day to his soul new avenues to truth and unsuspected paths of enchantment in the wonder world of discovery. It is the one force in the affairs of men which has never paused. Long, long ago we had great periods of literature, great periods of art, great periods of religion, and always what we attain in those regions to-day is mocked by the sublime achievements of the past. Indeed, are there not those who believe that religion and poetry reached long ago their apogee, and that for the future the feet of those who walk therein must needs go sorrowfully downwards from the transfigured mountain-heights ?

The One Thing that Moves Onward. Poetry has its ebb and flow, religion has its ebb and flow, morals and manners have their ebb and flow ; one thing alone is constant, one thing alone moves steadfastly forward. It is human knowledge. We cannot paint as Velasquez painted, we cannot sing as Shakespeare sang, we cannot feel ourselves in the relation to God which Francis of Assisi felt ; but we can say with the assurance of historical fact that the boy who to-day studies science at school knows more of the universe about him than even Newton knew. Our surgeons operate with less risk to life every day, and every year our steamers travel faster and with increasing comfort over the wildest seas. We print faster, we sow and reap quicker, we make and manufacture cheaper, and every year sees the wit of man improving on and surpassing the knowledge of his fathers. As obvious as the sun in the heavens is education in the affairs of men as the central and determining force in evolution.

And it is only because men have failed to apply education, have failed to use it for the highest and noblest purposes, that it has had so many powerful and brilliant enemies. What is the use of your fast steamers, they cry, of your reaping machines, of your cheap clothes and boots, of your halfpenny newspapers and your Nasmyth hammers, if life grows uglier at every age, if the lips of poetry grow increasingly dumb, and more and more the altars of God are deserted ? What avails your knowledge if there is less laughter and song in the world ? Behold your prisons, your lunatic asylums, your hideous barracks, your factory chimneys, and the blasted face of the country where your miners sweat out of sight of the sun—are these what you have to show us in exchange for ignorant peace and uninformed content ? Look, too—they may well cry—at the anæmic faces and bent backs of your clerks and factory-hands, and tell us whether progress leads further on in this direction, further and still further away from the deep chests, the broad shoulders, and the simple, happy minds of the age before your pestilent schoolmaster and his boast of book knowledge !

What Education Can Do. It is true enough that a misconceived Education has worked evil in the world. But we are only in the dawn of learning, and the faith of the most serious philosopher must be that life will become easier and not harder, pleasanter and not more irksome. Still more triumphant will the course of men become when education is perceived to be a means for obtaining control over the machinery of the brain, and when it will be as much a part of scholastic training to acquire the art of employing education as it now is to acquire information.

For it is certain that a weak man can train himself to become strong, a dull man to become bright, the intolerant to learn humility, and the erratic and unsteady to acquire steadfastness and earnestness. It is certain that education can produce intelligence even in the insane ; it is certain that education can cure many evil tendencies, either inherited or acquired, in the weak-minded. These things are clinical facts. How much more, then, shall the morally and mentally efficient benefit and develop under the influence of education, directly that education is particularly and most persistently directed to the creation of character ?

Education properly applied produces an efficient human being, fitted to enjoy his life, to work successfully in his profession or trade, and to serve as a pioneer for a more perfectly intellectual being in the generation to follow. It is not a haphazard process, which turns out a genius here or a dunce there ; it is a mathematical process which gives to every man, the most and the least gifted, greater and more certain control of his powers.

Learning by Rote. There are many men who confess that they learned nothing at school, but greater still is the number of those who must admit that they never learned at school how to use the knowledge they received at the hands of their schoolmaster. And yet it should surely be plain to the practical people in charge of education that a man may know the law by rote and yet fail as a barrister, that a man may be proficient in bookkeeping and yet fail as a merchant, that a man may learn husbandry in all its theories and practices and yet fail as a farmer.

We have such sayings as "He was born to succeed" to cloak our ignorance of the reason why one man fails and another man succeeds. Such a phrase has served in the past, but it will serve no longer. We have become righteously inquisitive, and have shaken off much ancient superstition ; we now hold pretty universally that there is a logical reason for everything. Why should one man succeed and another man fail in a profession which has been entered by both of them through the gates of the same examination ? Directly we realise that both of these men received an equal amount of information on the subject, and that both of them satisfied the examiners that they were equally efficient for that profession, we perceive that the reason of one man's success is his ability to apply his learning, and that the reason of the other man's failure is his inability to apply his learning. The only question that remains is whether it be possible to teach men how to apply their knowledge. Is this ability to make use of knowledge the immemorial secret of genius ? Is it the hidden answer to the perplexing problem of man's difference from man, or is it possible to implant and develop this power in the minds of the least responsive, and so bring almost to one level the laborious student and the brilliant scholar ?

Consciousness and Personality. It depends very much on the inclination of those who submit themselves to this discipline of the intelligence whether it succeed in the case of the heavy and the unsympathetic ; and even given this inclination, the man gifted with quickness of perception, and born with a ready and an intense sympathy, starts with a vast advantage over those who must painfully acquire this intellectual responsiveness. But every man who practises these exercises of the mind, be he slow or quick, will find himself studying with greater ease, and will discover a new and an increasing pleasure in adding to his stores of knowledge.

More and more the tedious as well as the brilliant will find themselves obtaining an even greater mastery over their minds, and feeling a finer command in the direction and administration of all the functions of their intelligence. Certainly they will be conscious of a deepening and a strengthening of their personality, an emergence from suffocating mists and enveloping miasmas towards their real and abiding selves, and will become every day better acquainted with themselves in what is destined to be the proper study of mankind—a knowledge of themselves.

Our Ignorance of Ourselves. At present, the mind of the mind, that Ego which drives the brain to work or permits it to rest, that mystery of all mysteries, the human consciousness, is the carpenter who has not learned the use of his tools. No wonder, then, that there are educational problems, and even critics of education itself; but when the mind of the mind has put itself to school and learned its lesson, then will the mind find little difficulty in acquiring information and even less difficulty in putting that information to practical service. We have only to cross-examine ourselves for a few minutes to find how ignorant we are of ourselves, and how clumsily we put to use the knowledge of which we possessed ourselves at school.

There are signs on all hands that men are awakening to the insufficiency of our present methods; there are even here and there evidences of the realisation by those in authority of the eternal and spiritual character of education. Professor Sidgwick and Sir Oliver Lodge have been the pioneers in this direction, and numerous other men, in attacking the present methods without any real system of their own, are preparing the way for the fuller and more scientific theory of education which is certainly destined to supplant our present process of "muddling through somehow."

The Soul for Study. It is certain as gravitation that men do now apprehend some objective in study beyond and outside the actual limits of education, some goal that as far transcends a competitive examination as the rays of Sirius outshine the flicker of a match. The present is a season of awakening—an awakening in the dark, which must needs mean groping—but already our trembling hands are touched by the faint hues of a new dawn. No one has more eloquently expressed this consciousness of awakening than Professor Macphail, of Glasgow, who concluded a recent address to medical students on the "Anatomy of Study" with these words:

> "And though I cannot tell where it exactly comes in, or in what it precisely consists, . . . I claim a Soul for study—a soul whose journey does not end in that studious training of brain and hands and hearts which makes physicians and surgeons worthy graduates throughout the length of their days, but a soul which, upward and around, to a goal above and beyond these things, is ever marching on. There is so much to be done in the day's work, so much to be endured, so much to be enjoyed, that there is often little time in the course of it for contemplation of the goal; but let us ever strive to keep green some cherished halting-places, where the rigours of the day's march can be forgotten, and where—
>
> 'In seasons of calm weather,
> Though inland far we be,
> Our souls have sight of that immortal sea
> Which brought us hither,
> Can in a moment travel thither,
> And see the children sport upon the shore
> And hear the mighty waters rolling evermore.'"

Above all things, it is essential to realise that education is worthless if it do not develop consciousness, and deepen the enjoyment of life. Nothing can be of service to the individual or to the race which does not bring out the fullest faculties of being and enlarge the vision of human destiny. To regard as education the cramming of a mind with facts and figures is to mistake brass for gold, and sea-froth for pearls.

Continued

PRACTICAL SOLID GEOMETRY

Definitions. Principles. Plan and Elevation. Solids in Simple Positions, and at Angles with Vertical Plane and Horizontal Plane

Group 8

DRAWING

12

Continued from page 1640

By WILLIAM R. COPE

SOLID geometry, or orthographic projection as it is sometimes called, is that part of the science of Geometry which enables us to represent on a flat surface, such as a piece of paper, which has only *two* dimensions—*viz.*, length and breadth—the form of solids, which have *three* dimensions—*viz.*, length, breadth, and thickness. The form and position of most solids can be shown by drawing two views only—*viz.*, (1) the *plan*, and (2) the *elevation*.

407 illustrates how both plan and elevation may be obtained. Fold a piece of paper at right angles, and place it on a table which adjoins a wall, so that one part of the paper rests horizontally on the table, and the other part vertically against the wall. Then place, say, a rectangular box on the paper, and trace its form *abcd* on the horizontal surface of the paper; this drawing shows the length and breadth of the object, and is called the *plan* of the box. Do not move the box, but next trace its form, *a'b'e'f'*, on the vertical surface of the paper; this drawing shows the height and length, and is called the *elevation* of the object. The surface, or plane, upon which the box stands is called the *horizontal plane* (H.P.), and the upright surface, upon which the elevation is drawn, is the *vertical plane* (V.P.). The crease or fold of the paper, where the two planes intersect, is the *intersecting line*, which is named XY or xy.

The plan and elevation are sometimes called *projections*, because each point of the object is projected or thrown upon the horizontal or vertical plane; thus, a' is the projection of A on the vertical plane, and the line which joins A and a' is called a *projector*.

The student should remember the system of lettering the corners of the object and their projections. Thus, if B denotes an actual corner of an object, then b shows its plan, and b' its elevation. [See **407** and **408**.] The latter shows the plan and elevation upon one surface when the V.P. and H.P. are opened out into one plane.

Definitions of Simple Solids

i. A *cube* is a solid contained by six equal squares [**409**].

ii. A *prism* has its two ends equal, similar, and parallel plane figures, and each of its sides is a parallelogram [**410**].

iii. A *pyramid* is a solid having a plane figure for its base, and its sides triangles, which have a common *apex*, or *vertex* [**411**]. Prisms and pyramids are named according to the shape of their ends and bases; thus, a hexagonal prism has a hexagon at each end [**410**], a pentagonal pyramid has a pentagon for its base, etc. [**411**]. The *axis* is a line passing through the middle of the solid. A *right* prism, cone, pyramid, etc., is one whose axis is at right angles to the ends or base [**410, 411, 414, 415**]. When the axis is not perpendicular, the prism, cone, pyramid, etc., is said to be *oblique* [**412**].

iv. A *sphere*, or globe, is a solid bounded by one convex surface, every part of which is equidistant from a point within, called the centre [**413**].

v. A *cone* is the solid generated by the revolution of a right-angled triangle round the perpendicular [**414**].

vi. A *cylinder* is a solid generated by the revolution of a rectangle round one of its sides [**415**].

vii. A *frustum* is that portion of a solid next its base left by cutting off the upper part. In a cone or pyramid the frustum is sometimes called a *truncated cone* or *truncated pyramid* [**416**].

viii. A *tetrahedron* is a solid bounded by four equal equilateral triangles [**417**].

ix. An *octahedron* is bounded by eight equal equilateral triangles [**418**].

x. A *dodecahedron* has twelve equal and regular pentagonal faces.

xi. An *icosahedron* has twenty equal faces, all equilateral triangles.

xii. A *section* is the cut part, or surface of separation, of a body cut by a plane.

Solids in Simple Positions. When working out the various problems which follow the student should make his drawings about four or five times as large as the diagrams here given, or according to dimensions given in the data. The projections should be represented by very thin lines, the visible edges of the object by thick lines, and the invisible edges by dotted ones. Sometimes it is best to draw the plan first, and at others the elevation; the student will be able to decide which should be first from the given data.

A very great help in solving problems in solid geometry is to make little models out of wood, or of pieces of cardboard fastened together. Then place the object as required according to given data in its proper relation to the vertical and horizontal planes, which may be well represented by a piece of cardboard cut partly through along the line XY, and folded at right angles.

On examining the following problems it will be seen that the elevation generally touches the line XY, and the plan is at any distance from the same XY; but the elevation may also be placed any distance above this line if required, according to given dimensions.

One should be careful to letter the corners correctly. The line XY and all horizontal ones should be drawn with the T-square, and projectors as well as other perpendiculars with the set-square.

Draw the plans and elevations of the following solids:

419. A Cube Standing on the H.P. (Horizontal Plane), with One Face Parallel to the V.P. (Vertical Plane). Draw the line *XY*, and below it make a square *abcd* with two of its sides parallel to *XY*. The elevation is obtained by drawing the projectors *de'* and *cf'* perpendicular to *XY*, and making the square *e'f'b'a'* upon *e'f'* as shown.

420. A Cube with One Face on the H.P., and with a Vertical Face Inclined at 30° with the V.P. For the plan, draw a square *abcd* with one side, as *cd*, making 30° with *XY*. From each angle of the plan draw projectors. Make *a'e'* equal to *ab*, and draw *a'c'* parallel to *XY*. Complete the elevation as shown.

421. A Cube standing on an Edge, with One Face making an Angle of 20° with the H.P., and its Vertical Faces Parallel to the V.P. Here the elevation must be drawn first, by drawing *a'e'* at 20° with *XY*, and on it construct the square *a'e'f'b'*. For the plan, draw projectors from each angle. Draw *dg* at any given distance from the vertical plane, and parallel to *XY*. Make *da* equal to *a'e'*, draw *af* parallel to *dg*, and complete.

422. A Square Pyramid, 2 in. High, standing on its Base, with One Edge making 30° with the V.P. Draw *dc* at 30° with *XY*, and on it describe a square *abcd* for the plan. For the elevation draw projectors from each angle to *XY*, and from *e* a projector to *e'*, 2 in. above *XY*. Join *e'* with *a'*, *d'*, *b'*, *c'*.

Note. The diagrams for the following problems, **423–429**, explain themselves.

423. A Cylinder, 2 in. Long and 2 in. in Diameter lying on the H.P. with its Axis at Right Angles to the V.P.

424. A Cone, 2¼ in. High and Base 2 in. in Diameter, standing with its Base in the H.P.

425. An Equilateral Triangular Prism, 2 in. Long, with Side of Triangle 1 in., lying on One of its Sides, with its Ends Parallel to the V.P.

426. A Hexagonal Prism, 2 in. Long, with Sides of Hexagon ¾ in., lying on One of its Sides, and Axis at Right Angles to the V.P.

427. An Octagonal Prism, 2 in. Long, with Sides of Octagon ½ in., lying on One of its Sides, with its Axis at Right Angles to the V.P.

Solids Having One or More Sides Inclined to the Vertical Plane

428. An Equilateral Triangular Prism standing on its End with One Side Inclined at 25° to the V.P.

429. A Hexagonal Prism, standing on an End with One Side making an Angle of 25° with the V.P.

430. A Tetrahedron, with One Face in the H.P., and One Edge at 40° with the V.P. Draw *bc* at 40° with *XY*, and on it describe an equilateral triangle *abc*. Join *a*, *b*, and *c* to the centre *d*. This is the plan. Draw projectors to obtain the elevation. To obtain the height, draw *dD* at right angles to *cd*. With *c* as centre and radius *bc* cut the perpendicular *dD* in *D*, then *dD* is the required height.

431. An Equilateral Triangular Prism, lying on One of its Rectangular Faces, with its Axis making 20° with the V.P. Draw *fe* at 20° with *XY*, and make *fe* equal to the length of the prism. At *e* and *f*, draw perpendiculars *fc* and *ed*, each equal to the edge of the equilateral triangle, and complete the rectangle *cdef*. Draw *ab* midway between *cd* and *ef*. This completes the plan. Draw projectors for the elevation. The height is obtained by constructing an equilateral triangle *Aed*, of which *Ab* is the height. The line *a'b'* is distant from *XY* a height equal to *Ab*.

432. A Hexagonal Prism, lying on One of its Oblong Sides, with its Axis making 20° with the V.P. Draw *jd* at 20° with *XY*, and from *j* and *d* draw perpendiculars *jg* and *da*, each equal to the *diagonal* of a given hexagon (*adAE* is a half of the given hexagon). Through *A* draw *ci*, and through *E*, *bh*, each parallel to *ag* or *dj*. This completes the plan. For the elevation draw projectors from each angle of the plan. The height *c'f'* or *h'l'*, is equal to twice *Ac* or *Eb*.

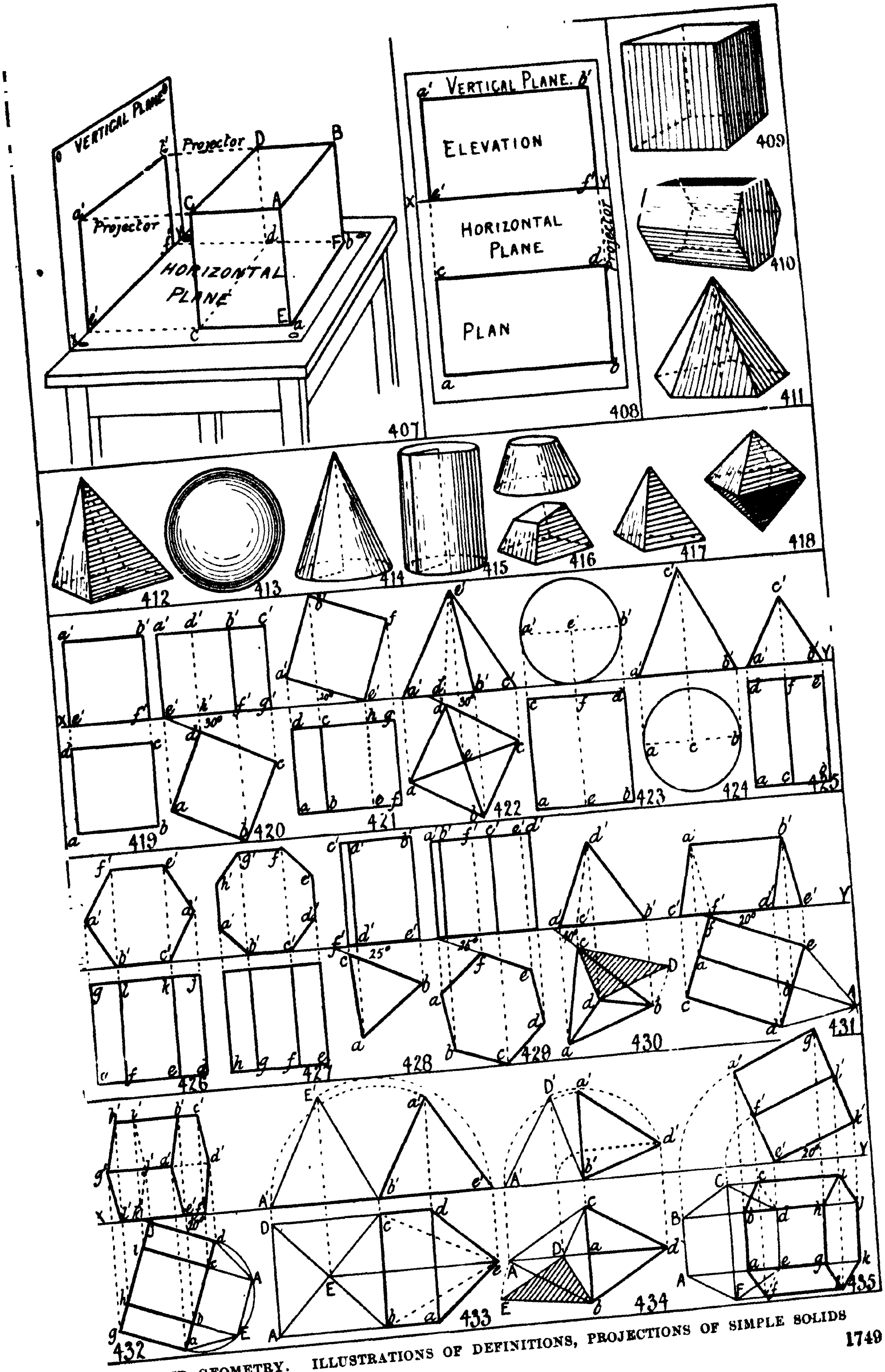
Solids with One or More Sides Inclined to the Horizontal Plane

433. A Square Pyramid, lying on One of its Triangular Surfaces, with its Square Base Perpendicular to the V.P. First construct the plan and elevation, when the pyramid is standing upright on its base, with one edge parallel to *XY*, as shown by *AbcD* in plan, and *A'b'E'* in elevation. Then turn the elevation *A'b'E'* so that *b'E'* rests on *XY* at *b'e'*, and *A'* at *a'*. Then *a'b'e'* is the required elevation. Draw projectors from *a'*, *b'*, and *e'*, to meet horizontals through *b*, *c*, and *E*. Then *abcde* is the plan.

434. A Tetrahedron, standing on One Edge, with its Axis Horizontal and Parallel to the V.P. As in **433**, first obtain the projections as if the tetrahedron were standing upright on a face with one edge perpendicular to *XY*, as *Abc* for plan, and *A'b'D'* for elevation. Turn this elevation until *A'b'* is vertical in the position *a'b'*, and *D'* at the point *d'*. Then *a'b'd'* is the required elevation. The plan *bcd* in then easily obtained.

435. A Hexagonal Prism, with its Axis Parallel to the V.P., but inclined to the H.P. at 20°. Construct the plan *ABCdeF*, when the prism is standing upright on its end, with an edge *AB* at right angles to *XY*. Draw projectors from this plan to meet *XY*. From *e'* draw *e'k'* equal to the length of the prism at 20° with *XY*, and erect perpendiculars to *e'k'* from *e'* and *k'*. Make *e'a'* and *k'g'* each equal to *dB*. Make *e'f'* equal to half of *dB*, and through *a'* and *f'* draw *a'g'* and *f'l'* parallel to *e'k'*. This is the required elevation. For the plan draw projectors from each angle of the elevation to meet horizontals from *A*, *B*, *C*, *d*, *e*, and *F*.

Continued



SOLID GEOMETRY. ILLUSTRATIONS OF DEFINITIONS, PROJECTIONS OF SIMPLE SOLIDS

[illegible]

RECAPITULATION

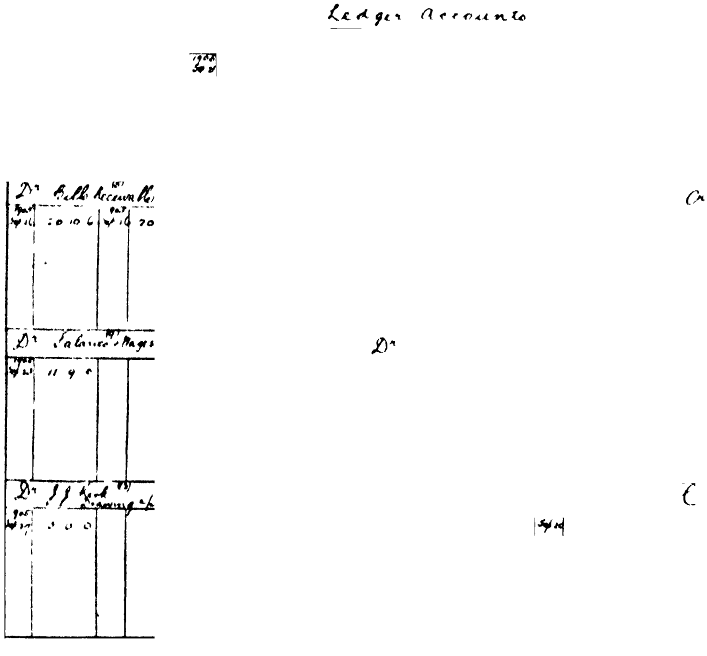
Double-entry Bookkeeping: A Recapitulation. Connection between Journal and Ledger. Epitome of Ledger Accounts

By A. J. WINDUS

It may be asserted without fear of contradiction that we are arrived at a crisis in the study of double-entry bookkeeping. In treating of the transactions related in Part VI., we "hastened slowly," but in order to reap the benefit of that policy, and avoid its perils, we must, before we proceed, attempt a recapitulation of the results attained.

Recapitulation. Nor can it be doubted that the usefulness of a review of this kind may be enhanced by combining with it fresh instruction on one or two matters closely connected with the work in hand. Accordingly, it is proposed to restate the aforesaid transactions in tabular form, with columns adjoining, wherein will be displayed the old-fashioned method of journalising items before posting to the ledger. The contrast between the old-style journal and the modern specialised books of original entry will be shown by means of the diagram annexed, which will also indicate the relation between such books of original entry and the ledger.

We shall then pass, by a natural transition, to the ledger itself. Messrs. Bevan & Kirk, it is true, keep several ledgers, but for the present purpose, let us imagine them to be various parts of one volume, each part being devoted to a special class of accounts, as trade creditors, trade debtors, and so on. As we advance in knowledge of our subject we shall agree that the multiplication of ledgers is a mere matter of convenience, and that none of the principles of double-entry is violated thereby. The same remarks also apply to the subdivision of the journal into day book, invoice book, and the rest.


Ledger Accounts
Dr Bills Account
20 10 6
70
Dr Salaries & Wages
11 9 0
Dr J J Kirk
Dr
Cr
C

Relation of Journal to Ledger. Our next care will be to trace the connection between (*a*) the journal and the ledger—where the former is the sole book of original entry; and (*b*) the books of original entry and the ledger, where the journal has been subdivided. In the latter case, it should be remembered that the journal still exists as *one* of the books of original entry, although in an abbreviated form.

With the object of clearly demonstrating the effect of posting from the journal to the ledger, a *partial* view of the ledger will be given, comprising merely the accounts and items mentioned in the journal entries.

We shall do well to concentrate our attention upon the synopsis now presented. It contains the sum and substance of much that has been discussed in the previous chapters of our course, and upon the true understanding of it our progress in the art and science of accounting largely depends.

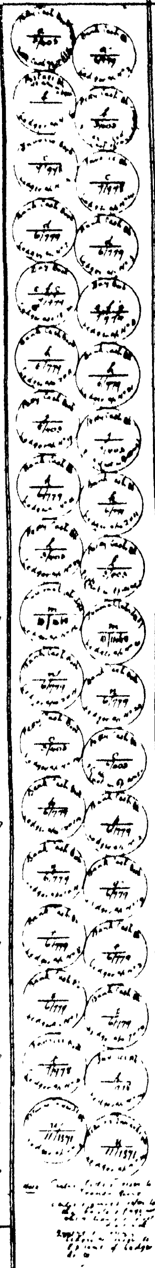
Old style

JOURNAL (unabridged)

Part VI pp 777 and 779	Sept 1905	Transactions		September 1905		Dr			Cr		
				20th							
a	20	Cheque £5 drawn for Petty Cash	B	Cash Dr	1	5					
			D	to Bank	2				5		
b		Stamps purchased 5/	B	Stamps Dr	6		5				
			E	to Cash	1					5	
				21st							
c	21	Invoice passed for goods from Ord & Mackay £57 10 0	B	Goods Dr	3	57	10				
			D	to Ord & Mackay	14				57	10	
			A	Allday Dr	14	1	5	9			
d		Mr Allday purchased for cash goods value £1 5 9	E	to Goods	3				1	5	9
			B	Cash Dr	1	1	5	9			
			D	to Allday	17				1	5	9
			A	Bank Dr	2	1	5	9			
			E	to Cash	1				1	5	9
		Goods sold on credit as follows	A	Harold Springer Dr	18	2	12				
e		Harold Springer £2 12 0	A	J Bruce Dr	19	11	4	8			
f		J Bruce £11 4 8	A	Aird Bros Dr	20	44	9	10			
g		Aird Bros £44 9 10	E	to Goods	3				58	6	6
				22nd							
h	22	Recd from Brown & Co. Ld cheque value £10 1 9 in settt of their a/c £10 6 11 less 2½% = 5/2	B	Cash Dr	1	10	1	9			
			C	Disct Dr	11		5	2			
			D	to Brown & Co Ld	21				10	6	11
			A	Bank Dr	2	10	1	9			
			E	to Cash	1				10	1	9
i		Drew on J Wake for £20 10 6 at 3 mos date in settt of a/c [illegible]		No entry see p 1090							
				23rd							
j	23	Paid from Petty Cash salaries & wages as per Salary Book £11 9 0	C	Salaries & Wages Dr	9	11	9				
			E	to Cash	1				11	9	
			A	Rice & Sons Dr	13	50	9	6			
k		Paid Rice & Sons cheque value £49 4 3 in full of a/c £50 9 6 [illegible]	D	to Bank	2				49	4	3
			F	to Discount	11				1	5	3
				25th							
l	25	Paid postage of parcel to Williams Bros, Capetown 5/	A	Williams Bros Dr	22		5				
			E	to Cash postage of pcl to Capetown	1					5	
				20th							
m		Accepted Henry Norgate's draft at 60 days £55 4 11 payable at Commercial Bkg Co in settt of a/c to 1st Sept	A	Henry Norgate Dr	16	55	4	11			
			E	to B P a/c No 15	4				55	4	11
				26th							
n	26	Recd and discounted J Wakes acct for £20 10 6 the bank charging 3/ for discount	B	B R a/c Dr	5	20	10	6			
			D	to J Wake	23				20	10	6
			A	Bank Dr	2	20	7	6			
			C	Discount Dr	11		3				
			E	to B R	5				20	10	6
				27th							
o	27	Paid from petty cash cost of advt for town traveller 3/ and 1/9 for brown paper	C	Trade Exps Dr	10		3				
			E	to Cash Advt for town traveller	1					3	
			C	Trade Exps Dr	10		1	9			
			E	to Cash Brown paper purchased	1					1	9
p		Mr Bevan drew £5 and Mr Kirk £3 on private a/c	A	Wm Bevan Drawings a/c Dr	12	5					
			A	J J Kirk do Dr	1[illegible]	3					
			E	to Cash	1				8		
				28th							
q	28	J Bruce paid £11 4 8 less disct of 2½% = 8 5	B	Cash Dr	1	10	16	3			
			C	Discount Dr	11		8	5			
			D	to J Bruce	19				11	4	8
				29th							
r	29	One quarter's rent of business premises £27 10 0 paid by cheque	C	Rent a/c Dr	8	27	10				
			D	to Bank	2				27	10	
				30th							
s	30	Recd of Jones & Co cheque for £29 8 2 in payt of commn £27 6 0 and exps £2 2 2 to 30th June 1905	B	Cash Dr	1	29	8	2			
			F	to Commission	7				27	6	
			F	to Trade Exps per a/c Jones & Co to 30/6/05	10				2	2	2
			A	Bank Dr	2	29	8	2			
			E	to Cash	1				29	8	2
t		Invoice passed for goods received from Ord & Mackay £46 15 3	B	Goods Dr	3	46	15	3			
			D	to Ord & Mackay	14				46	15	3
			B	Goods Dr	3	3	7	4			
u		Goods retd by Aird Bros (wrong pattn) £3 7 4	D	to Aird Bros goods retd wrong pattn	20				3	7	4
						£469	15	2	469	15	2

DIAGRAM

Debit	Credit
September 1905	



Continued

BOYS' SUITS

Drafting and Making Banded Knickers. Tracing and Making up Breeches. A Norfolk Jacket. The Trouser System

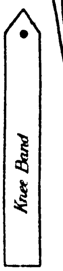
By Mrs. W. H. SMITH and AZÉLINE LEWIS

Banded Knickers. The knickers with which we have now to deal are intended to accompany the coat just drafted.

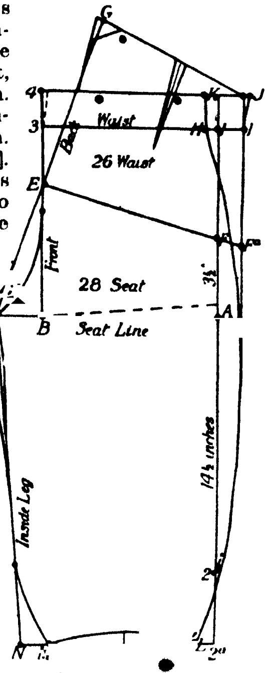
Side length, from the hollow of waist to side of knee, 20 in.; inside leg, 12 in.; seat, 28 in.; waist, 26 in.; knee band, 10 in. Working scale, half waist, 13 in.; half seat, 14 in.; ¼ in. turnings are allowed on all seams.

Drafting the Knickers. These are drafted in the same way as the previous knickers, with the following exceptions: 1 to 2, side length; 2 to 2^a, 3 in.; 3 to H, half waist; back line to I, half waist and 1¾ in. This allows 1 in for turnings, and ¾ in. to be taken out in a dart, which is made 3 in. from J, and terminates about 2 in. below waist line [**48**]. The object of this extra ¾ in. added to the turnings is to give plenty of room from 1 to C, otherwise the knickers will drag at those points.

Make J on the line above I, and K above H on same line; 2^a to L, 1 in.; L to M, half seat, less ½ in.; M to N, 1 in. Draw line from N to C, curve from C through B^a, to within 1 in. of E. Three inches up from N make a dot; curve from M through the dot to D, and from D to E. Curve from L ¼ in. to right of 2, through F^a and I, to ¼ in. to right of J, and from seat-line through H to K.



49. BAND



48. DRAFTING FOR KNICKERS

Make a dot midway between L and M, hollow the underside ½ in., and round the top side ¼ in. [**48**]. The top side is to be fulled on for knee-band. The pocket openings are about 5 in. down, from I and H. The band should be 3 in. more than the actual size, and 1 in. wide when finished [**49**].

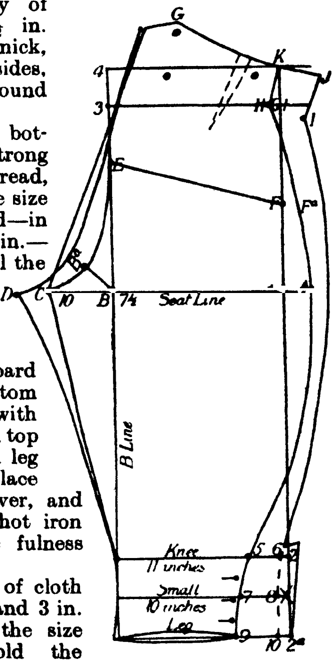
Trace the pattern off as in previous drafts, leaving an inlay on the outside seam of back part 4½ in. up from the bottom. The inlay must be thread-marked.

Making the Knickers. These knickers are made in exactly the same way as the others, with these exceptions: The outside seams are not stitched until the bands are on, and the inside leg seams are only stitched up 4 in. from the bottom.

The bottoms are prepared in the following manner: Take a piece of silesia 2 in. wide and 4 in. long, fold through the centre, baste the silesia on the right side of cloth (raw edges together) from the nick to the bottom. Machine the edge, remove the basting, turn the silesia over; baste, machine on the right side from the bottom to the nick, ⅛ in. from the edge. Take a piece of linen 1¾ in. wide and 4½ in. long, turn the edges in ¼ in., and the top ½ in.; baste to the inlay of back part ½ in. above the nick, along both sides, and machine round the edges.

Gather the bottoms with strong waxed thread, draw in to the size of the band—in this case 10 in.—and shrink all the fulness out in this manner. Place the large end of a sleeve-board inside the bottom of knickers, with the gathers on top of board, and leg underneath; place a wet rag over, and press with a hot iron until all the fulness is gone.

Cut a strip of cloth 2½ in. wide, and 3 in. longer than the size required; fold the band, make nicks 2 in. from end for the tongue, and 1 in. from the other for the wrap. Place the band on the top of leg, right side underneath, with the nick of tongue to the turned-in edge; baste along and machine ¼ in. from the edge. Remove the basting, turn the band over, allowing the



50. DRAFTING FOR BREECHES

raw edge to overlap the seam ¼ in. Baste, making the corner neat; stitch all round ⅛ in. in from edge, and press on the wrong side over a damp cloth.

Join the outside seams and press. Open the knickers right side uppermost, and bar-tack the top of opening; then finish off, and put in the linings as described for first knickers.

Breeches. Side leg, 20 in. Inside leg, 12 in. Seat, 30 in. Knee, 11 in. Small, 10 in. Bottom, 10½ in. [50].

These are drafted on the same principle as previous knickers, with a few exceptions. 1 to 2 is side leg to knee (20); 2 to 2^a, 4 in.; X midway between 2 and 2^a. Square lines out from 2, X, and 2^a, also from B on seat-line to bottom.

B line to 5, half the knee (5½); place this amount, 5½ in., on B line, and make dot 6 the full knee measure, plus 1½ in. (12½). B line to 7, half the small of knee (5 in.); place this amount on B line, and make 8 the full measure and 1½ in. (11½). B line to 9, half the bottom measure (5¼); place this amount on B line, and make 10 the full measure, plus 1½ in. (12).

Draw line from knee to C, slightly curve ¼ in. to the left of this line, curve ¼ in. to the left of B line at the bottom, and continue to D. Curve the outside seam from 9, through 7 and 5, to 1 in. to the right of A, and on to H and K; and from 10, through 8, 6, 1½ in. to right of A, to I and J. Curve the bottom of knickers ¼ in. above and below the leg line [50].

Tracing the Pattern. In tracing the pattern off take the fore part, trace along the bottom curved line, then from 9 through 7 and 5 to K, along the top (from K to 4), waist-line (H to 3), through the broken line and 3, B^a to C, and to the bottom of knicker. Trace the back part along the upper curved line at the bottom, and from 10 through 8 and 6, to I and J; from J to dot beyond G, on to D, and from D to bottom of knicker. Leave an inlay of 1 in. on the outside seam of back part.

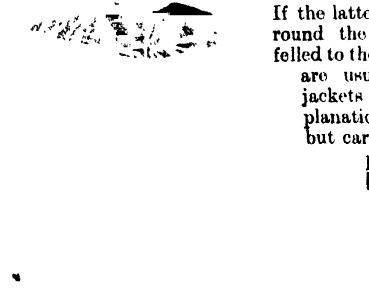
When cutting the cloth make nicks midway between knee and seat-line on both sides, as these must be put together when making, or they will twist when worn.

Diagram 50 also shows position of buttons and buttonholes.

Making up the Breeches. These are made like the banded knickers, with a few exceptions. The stay for the buttonhole side of knee-opening should be 4 in. wide and 4½ in. long, whilst the bottoms should be bound with best Prussian binding. This binding is basted on the right side, being held rather tightly (the cloth must not be stretched). Stitch, remove basting, turn over, and fell on the wrong side.

Four buttonholes are worked on the fore part, ¾ in. apart, the first one being ¾ in. from the tack.

If the knickers are not lined throughout, they must have a curtain, or wing, placed under the waistband, which should be 6 in. deep at the back, and 4 in. at the side; the bottom edge must be turned in and stitched, the centre caught to back seam, and the sides felled to the pockets [51]. Face the forks with a little light lining.



51. BREECHES COMPLETED

Norfolk Jacket. A Norfolk jacket, to wear with the breeches already given, can be made with or without a step collar. If the latter, it is simply turned in round the neck, and the lining felled to the cloth. Patch pockets are usually put on Norfolk jackets; these call for no explanation, as they are so simple, but care must be taken not to put them on too tightly [52].

The pleats are made in this way. The cloth must be cut double the width they are required to be when finished—in this case it is 4 in. for a 2 in. pleat. The two edges must be serged together (the cotton should not be drawn too tightly, or a hard ridge will result), then press the pleat on the wrong side with the seam in the centre.

Baste to the right side of coat, rather "easy," from the shoulder to the bottom [for position see 52]. Turn the coat over, and sew the pleat to the coat ½ in. on either side of the seam before the lining goes in. It has one pleat down the centre of back, made in the same manner. Finish off the coat as previously shown.

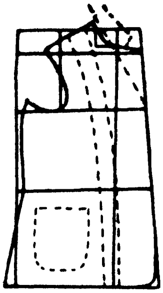
The Belt. We are now ready for the belt. Take a strip of linen canvas 2 in. wide and 3 in. more than waist measure. Point one end for the buttonhole. Cut the cloth 3 in. wide and ½ in. longer than the canvas; baste the cloth to the canvas, leaving ¼ in. at each end. Serge the cloth to the canvas without letting the stitches show through, as they remain.

Turn the cloth in neatly and rather easy at the pointed end, and face the belt with a strip of lining to match the coat. Work the buttonhole on the pointed end, and sew two buttons, 1 in. apart, on the other.

The belt can either be stitched to the centre-back and side seams, or loops made of the cloth can be sewn to the side seams, and the belt slipped through; in any case it must be stitched to the centre of back.

The Trouser System. Waist, 29 in.; seat, 32 in.; knee, 16 in.; bottom, 15 in.; side length, 36½ in.; inside leg, 25 in. ¼-in. turnings are allowed.

The Drafting. Draw side length 1 to 2 (36½ in.); mark up to A, length of inside leg, 25½ in.; this leaves 10 in. for what is called the rise of the body. Square a line from A about 12 in.; A to B, half of seat, 8 in.; A to C, two-thirds; C to D, one-twelfth; B to B^a, one-twelfth plus ¼ in. Square line from B, raising the ruler ½ in. above A. If this is omitted, the top of the trousers will be too tight in front waist. B to 3, half of seat, plus 1 in.; 3 to 4, 2 in. Draw lines from 3 and 4 to side-line, then follow directions for banded knickers for the waist portion.



52. NORFOLK JACKET

2 to 5, half leg, plus 2 in. (15 in.); 2 to 4, 1½ in. Draw line from L, through F^a, to I and J. Square a line from 5, and make 6 from inner point of 5 half knee-measure. L to M, half bottom, less ½ in. M to N, 1½ in; 6 to 7, 1 in. Draw lines from M, through 6, to C, and from N, through 7, to D. Mark up ¾ in. from bottom, midway between L and M, and curve from these points [53].

The front and back must be traced and cut out in the same way as for knickers.

Making the Trousers. Material required, 2½ yards; this will leave pieces for repairing.

The making of trousers, as of any other garment, must be carefully done if they are to fit.

Leave 1½ in. up the back, to let out if required; also 1½ in. to turn up at bottom. Remember to put in the marks at knees, which must be exactly opposite each other when the trousers are tacked together.

If they are to be lined cut the linings first, taking care to cut them ½ in. larger at top and under-sides—as at C and D—to prevent splitting at those parts where there is most wear, because cloth made from wool is elastic, while cotton is not.

Cut the fly to fit fronts, as shown on diagram for knickers. Put linen inside and silesia outside to match, canvas or linen, 2 in. wide, round the tops, and stays on the places where the buttons will be sewn. The fly must have special attention to make it fit well. Baste a piece of linen round the fork, as shown in the diagram [from 4 to B^a, 53]. This is to prevent the fly from tearing down at that part, where there is so much strain when putting on or working. The fly must also be faced up with silesia, and the button part must have double linen put on, close to the seam, quite "easy," so as not to tie the front. This must also be faced with silesia.

The Pockets. The pockets must have good stays at top, and be well secured top and bottom. This is very important.

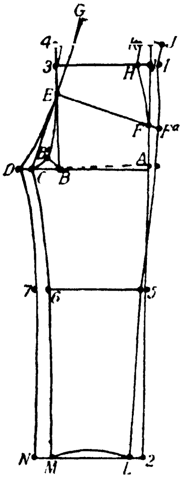
When the trousers are ready for machining care should be taken that the tension of the machine is set right—that is, the stitch locked in the middle—so that the stitch is the same on both sides; if not, the seam will give way, and probably cause a good deal of trouble.

When ready to press slide the leg on a duplex or double sleeve-board, and press well. Good trousers makers shape the legs to the form—that is, they shrink the legs in at shins, to form the calf; also at the back of thighs, to form the round at that part; the instep is also shaped, as well as the heels. This pressing is done on a piece of cloth on a table, and a crease put up the fronts, where the shinbone is, to the tops [45]. If lined, proceed as for knickers.

Boy's Overcoat. We have now to deal with the making of overcoats for boys between ten and fourteen years of age.

Measurements. Neck, 14 in.; back length, 15 in.; length of coat, 33 in. or more, as desired. Back 6 in; elbow, 17—to wrist, 26 in.; breast, 28 in. Working scale, half-breast, 14 in

These measurements are taken over the under coat, allowing 2 in. more than breast measurement, and 1 in. on length of sleeve. Notice that the width of back and front shoulders is greater for boys than for girls.



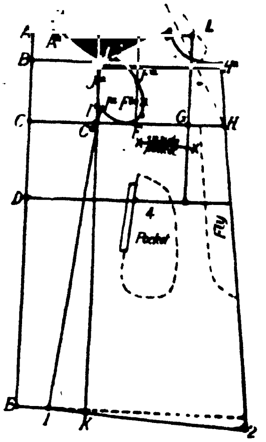
53. DRAFTING FOR TROUSERS

The Drafting. For the back, square a line 3 in. from top of paper, and 2 in. in from edge, and letter the corner A [54].

The drafting is much the same as that of the coat with step collar, with the following exceptions. B to C, one-third, plus ½ in.; A to D, length of back, plus (1¾ in. 5¾ in.); A to E, length required. Draw lines at right angles from B, C, D, and E. A^a to A^b, ¾ in.; C to C^a, one-third of breast, plus 1½ in. (this addition of an extra ½ in. in width and in length makes the back wider by 1 in., and longer from A to C, as required for boys. B to J measures the same. Square a line from J to bottom of coat; make K.

K to 1, one-fourth of breast (3½ in.). Draw shoulder-line slightly curved from J to A^b, and A^b to A. J to J^a, 1½ to 2 in., according to style—this is the back pitch for sleeve. C^a to I, one-twelfth (1¼ in.) of breast; I to I^a, ½ in., draw a line from I to I^a. A slit can be left in back if desired, when about 4 in. should be left below the natural waist-line, and an extra piece to turn in for facing and going under, to prevent the back from gaping open. In this case, a seam is required in centre-back.

The Front Drafting. C to F, two-thirds of breast (10⅔ in.); F to Fᵃ, one-fourth of breast (3½ in.); Fᵇ is midway between F and Fᵃ; Fᵇ to X, ¾ in.; C to G, half breast, plus ½ in. The half inch is lost, so to speak, by the curving in at top of side, where the arm joins the back. Square line from waist through G; make L on neck-line; G to H 3½ in. more than size—this quantity will give a nice lap-over for ease. Hᵃ 3 in. from line G. Draw line from Hᵃ through H to bottom of garment, add 1 in., and make dot 2; then connect with 1 [**54**].



54. DRAFTING FOR OVERCOAT

For the drafting of collar, follow directions for step collar, with the exception that Hᵃ curve is not raised ½ in. Draw the neck, shoulder, and armhole curves as in previous draftings. Draw a line from K to I, and on to J, for side-seam of back.

Drafting the Pockets. From G line on waist to 4, 4 in.; draw a line in a slanting direction [**54**] 1 in. above and 5 in. below 4, for opening; the welt is 1 in. to the left of opening. The pocket proper is 12 in. long, 6 in. wide at the bottom, and shaped as in the same diagram, and should go 1½ in. above the opening.

A breast pocket is now inserted in the lining of the left fore part, not outside, as formerly [for position, see **54**].

The Sleeves. The sleeves are drafted as has been previously shown, except that the bottoms should be 1 in. wider, and an extra ½ in. added to the elbow.

Directions for collar have already been dealt with, but for an overcoat the fall should be about 2 in., and the step about 1½ in.

For position of fly, diagram **54** should be referred to. It should extend 15 in. below H, and be 2 in. wide.

Material and lining required are about 2 yds. of 54-in. cloth, and ¾ yd. of sleeve-lining, 1 yd. of canvas, ½ yd. best black linen. It is advisable to get canvas that has been shrunk.

Vertical Welted Pocket. The linen stay must first be put on the thread-marks of opening on the wrong side, as previously shown. The back of pocket must have a facing of cloth 2 in. wide, and ½ in. longer than the opening. Place this on the right side of coat, wrong side uppermost, close to the thread-marks of opening, and ½ in. above and below the opening.

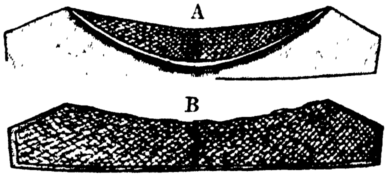
Place the pocket lining on the facing, 1½ in. above the opening, baste to the coat, and stitch along the edge. Now stitch the other part of pocket lining and linen stay to the top of welt, as for vest pockets.

Baste a linen stay to the centre of welt; cut the pocket-opening to within ½ in., making slanting notches on both sides of either end, to allow the pocket to go through easily. Stitch the edge of facing to the pocket lining, put the linings through the opening, machine the edge of welt, and again ½ in. below, and proceed with the welt as in vest. Then baste the pocket round, taking in the linen stays, and stitch. Be sure and well secure the ends of pockets to the canvas after it has been inserted, and place the linen stays from pockets to armholes, as in previous lessons. This is most important for an overcoat.

Inside Breast Pocket. We must now proceed with the inside breast pocket. The lining and facing of left fore part must be carefully fitted, and the pocket-opening thread-marked before the pocket is inserted. If the lining is of Italian, the pocket must be jetted, or piped, with the same; if of cloth, it must be jetted with cloth.

First place the linen stay on the wrong side, as previously shown. Take two strips of Italian, 1½ in. wide and ½ in. longer than the opening; fold each piece through the centre; place one above and one below the pocket-opening, with the folds close to the thread-marks, and a seam beyond at either end. Baste to the cloth, and stitch ⅛ in. above and below the thread-marks; remove the basting, cut the opening to within ½ in., slightly notch each end, fold the Italian back to the wrong side of facing, and baste the edge above and below the opening, pressing the cloth down so that the Italian cloth will show $\frac{1}{16}$ in. above and below.

Take two pieces of lining for the pocket, 2 in. wider than the opening and 7 to 8 in. long; face the top of back part with a strip of Italian 2 in. wide. Baste together; turn in the lower edge of facing, and stitch to lining; turn the coat-facing over, wrong side uppermost. Place the front of pocket-lining over the opening with the lower edge away from the worker; baste the other edge ½ in. below the pocket-opening; turn the fore part over with the lining in the same position; machine the edge $\frac{1}{16}$ in. below the seam; and crease the pocket-lining back in its proper position.



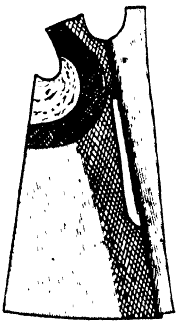
55. COLLAR AND FALL READY FOR FACING

Now place the back of pocket on the wrong side of coat-facing, 1 in. above the opening, with the pocket-facing underneath; baste, turn the fore part over, and stitch the edge $\frac{1}{16}$ in. from the seam. Remove the basting, draw the edges of the pocket-opening together with a few stitches, to keep it closed until the pocket is finished; press the corners back with a needle, and finish the pocket, not forgetting the bar tacks at the ends of opening, as it is most important that these should be well secured.

The sleeves and collar are made and put on as already shown [55 A and B].

Making an Overcoat. The fore parts of the coat must have extra canvas from the shoulders extending to the bottom of armholes. The lining and facing should be well padded with wadding—as from F to I^a [54], where there is a slight sinking in—which is stitched to the lining [56]. The armholes should have a linen stay extending from shoulder to 2 in. beyond side seams. It must be held a little tightly round the back of armhole and put on before the sleeve is inserted; the latter, after being inserted, should have a small roll of wadding about 5 in. long, and ½ in. wide (before being rolled) tacked on the top of sleeve on the inside before the lining is felled in place.

The Fly. We have now to consider the fly. We may assume the fronts are prepared, with the stays, canvas, and lapel padded, as previously shown. Take the left fore part, place it on the table, right side uppermost; take a piece of Italian 2 in. wide, place this on the fore part, wrong side uppermost, 1 in. above and below the opening, which must be notched a seam top and bottom. Baste and stitch from notch to notch; remove the basting, turn in the Italian, baste the edge on the inside of coat, working the cloth in $\frac{1}{16}$ in. Turn the fore part over, stitch from notch to notch close to the edge and also ¼ in. in; fit the facing to the fore part, leaving it rather full at the lapel. Then notch the facing at the top and bottom of opening.

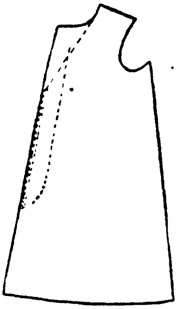


56. INSIDE OF LEFT FORE PART

Remove the facing from the coat, place it on the table, right side uppermost, with the neck to the left; place a strip of Italian on the opening, and on this a double strip of linen 2½ in. wide when folded. Baste the edges together, stitch and remove the basting; turn the linen and Italian over and baste the edge 1 in. in, working the cloth in ⅛ in., and stitch ¼ in. in from edge.

Now replace facing, with the right side facing that of fore part, and baste together.

The lapel portion of facing should be left quite "easy" from H to 1 in. below this to allow for turning over without tightening it, and thus allowing it to set quite flat [54].



57. FLY OF LEFT FORE PART

Machine-stitch lapel, as in boy's coat with step collar, to H. Remove the basting, press the seams, and trim them neatly. Turn the facing over; treat the lapel as in former lesson, baste the fly in position, and machine 2 in. away from the edge on the right side, but not through facing, rounding the bottom of fly, as in drafting [56 and 57].

A row of stitching should now be machined down each front, round lapel and collar, and again ¼ in. in from edge.

Space and work the buttonholes. The first should be 1 in. from the end of lapel at H. They should be 4½ in. apart, and ½ in. from edge.

Secure the fly to the coat at the top and bottom with invisible stitches, also between each buttonhole.

The right fore part is treated in the way already shown. The buttons are put on 3 in. from the edge of coat, on which an extra strip of canvas, 2 in. wide, should be placed. The centre of the canvas should be placed where the buttons are to be sewn on.

The coat can then be finished off and pressed.

Continued

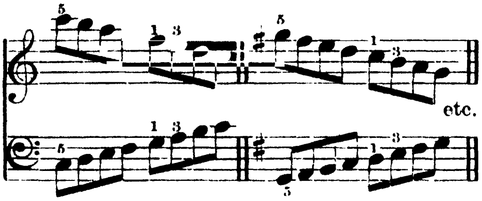
continued from page 1508

SCALE PLAYING

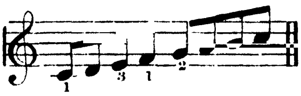
Stretching the Hand. Playing with Hand Movement. Arpeggio Playing. Double-note Passages. Weight Touch. Scale Fingering

By M. KENNEDY-FRASER

HAVING become familiar with the scales, taking each hand separately, we must take them next with the hands together in contrary motion, thus:



Passing under Thumb. In learning to play the scale the *reverse way,* ascending with right hand and descending with left, begin by passing the thumb along under the fingers as soon as it is free to leave its key, and so have it "prepared" over the fourth note of the scale. In placing it on F, and the forefinger on G, there may be a slight—a very slight—double lateral movement of the wrist. But this must be so *very* slight as not to disturb the general impression of the hand continuing to lie obliquely across the keys. In scale playing there is no stretching of the fingers; slight lateral movements of the wrist and a steady lateral movement of the arm *bring* the fingers over the keys. But in piano playing, nevertheless, stretches of the fingers and hand are sometimes necessary. Here, again, the muscular conditions must, as far as possible, be those of ease—freedom from restraint.



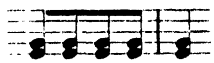
Stretching the Hand. For octaves and tenths, etc., we must let the stretching be gradual and gentle, and so achieve it without rigidity, and be able to retain elasticity of touch. Gentle exercises away from the piano, practising alternate out-stretching of all the fingers, and gentle but complete reclosure of the fist, is good for this and for the general health of the finger and hand muscles. All kinds of easy though full-sweeping gymnastics of the hand and arm are indeed good for the pianist, provided always there is no rigidity.

The general principles of all such gymnastics are these: To use fully one set of muscles, and to follow that up by immediately using the opposite set, taking care, however, never to use the two opposing set of muscles simultaneously. Stretch out the arms and then refold them, stretching them at all kinds of different angles and altitudes in their relation to the body; let all the motions be full—go as far as may be in either direction, but always *gently.* Remember to use such gymnastics *after*, never *immediately before,* playing.

Octave playing brings us to hand movement—*i.e.*, playing without any movement of the fingers relatively to the hand, but with movement of the whole hand instead, relatively to the forearm.

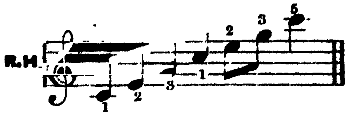
Playing with Hand Movement. This was, till recently, termed "wrist action." This downward movement of hand at knuckle end —hand touch—"need not exceed the distance from key-surface to key-bottom"; but if, as in the case of finger movement, we play (in slow time) with a preliminary lifting of the hand, this must be followed by its *falling* on the keys, thus relaxing the up muscles and making key-contact without any hitting. In the latter case, we must be careful never to *think* the lifting of the hand, but always to "*think* key-movement" instead. For if we attend to this upward movement of the hand, which is not essential to tone production, but is merely a form of muscular gymnastics for the freeing of the muscles, we may overlook the *essential,* that feeling of the resistance of the keys before and as we move them into sound, which is the *only* way of making sure that we get what we want from them.

Our attention must always be given to the making of *sound* "by using our sense of key-resistance, and by listening for the beginning of the sound." In playing repeated notes thus: we must bear in mind that the sound is reached before the bottom of the key-bed is reached, and that in good pianos with repetition action it is even not necessary in very soft passages to let the key rise to its highest level between the repetitions, and that these, therefore, can be performed with a very slight up and down swaying of the key.



Position of Fingers and Wrist in Hand-touch. Now note in connection with hand-touch, or so-called wrist-touch, that: (*a*) "The fingers do not move relatively to the hand. Fingers should not move during key descent, except in finger-touch. (*b*) The normal height of wrist is about level with knuckles or slightly lower. This may vary, but rapid octaves are found, as a rule, easier with the wrist-level slightly higher than the normal. (*c*) The wrist must alternately rise and fall, slightly, when a passage requires the thumb on alternate black and white keys; wrist lower for black than for white keys, movement not greater than will suffice to keep elbow quiet." [Matthay.]

Arpeggio Playing. Arpeggio playing now calls for attention. Arpeggi are the notes of chords played in succession; thus in the chord of C:



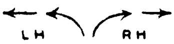
and in extended arpeggio passages the thumb, as in scales, passes, and is passed by, the fingers. The hand, in such passages, must lie still more obliquely to the keys than in scale playing. Extended arpeggi, in short, are just big-striding scales, and the scale habits here call for slight exaggeration. "The arpeggio," says Matthay, "in addition to the normally outwardly-turned position of wrist (as in the scale), requires slight lateral movements of the hand and wrist to enhance the lateral stretch of the thumb and fingers."

Well oil your wrist, so to speak, by omitting all contrary exertions, and *gently* rest on the connecting note. Preserve the oblique line of hand to keys even to the extreme ends of keyboard, following the hand up with a lateral movement of the arm.

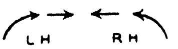
The oblique position of hands for single-note scales and arpeggi is, as we have seen, one that causes a slight turning in of the hands towards the body.

Double-note Passages. For double-note passages, on the other hand, it takes the form of (*a*), from the centre of keyboard outwards, and this other form (*b*) from extremes of keyboard towards the centre. In short, in such passages the hand is turned in the direction the scale is travelling. All such laterally modified positions of the hand must be assumed and retained with the greatest possible ease—*i.e.*, without any stiffness induced by the interference of the contrary muscles. In playing double-note passages *legato*, the connection can only be maintained at the cross-over junction by *one* of the two notes. Realise this, and rest gently on this one note with fifth finger or thumb while taking up the new position for the next two. And remember to leave the fifth finger bendable, as learned in the Daily Test.

(*a*)



(*b*)



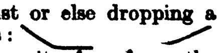
The Three Movements. We have spoken of finger-*movement* (the only movement available for a real *legato*), hand-movement, used for rapid double-octave and sixth passages, etc. Besides these we also require arm-movement, the movement we use to carry the hand and fingers to the keyboard at the beginning and end of phrases, and also for slow successions of chords and single notes. In approaching the keyboard, let the arm gently fall of its own weight, but not necessarily of its *whole* weight. Single detached notes are mostly played by the arm.

So-called "portamento" passages, indicated by a combined use of the staccato dot and the legato slur, thus which we find frequently in Chopin's music, for instance, and which are really a duration emphasis, are played invariably by arm-weight and frequently by arm-movement.

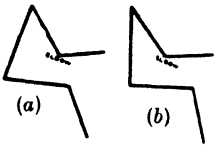
Muscular Combinations. We have seen that the weight of the arm and the exertion of finger or hand, or both, are the muscular agencies we use against the key to move it. These are our artist's colours—our palette. From these, and from combinations of these, we get all our effects. Thus, if in finger-movement we eliminate both arm-weight and hand-exertion, we get light, prestissimo passage playing. If we add hand to finger exertion, during finger-movement, we get a more robust tone and less speed. If we add arm-weight to finger and hand exertion, during finger-movement, we get any range of tone the instrument can yield, but no more than a limited degree of speed. The same thing applies to hand-movement. With it, when we wish speed rather than tone amount, we eliminate arm-weight, and so on. Such combinations do not affect agility and tone amount only; they must also be most carefully chosen, that we may obtain the desired tone *qualities*. When muscular exertion takes the lead and calls on arm-weight to follow, the tone is bright and rousing.

Weight Touch. When arm-weight, on the other hand, lazily tends to fall, and is, as it were, tardily conveyed to the keys by the muscular exertion, then the tone, thus more gradually induced, has a character which betrays its origin and affects us with its inherent quality, persuasive, insinuating, stealing upon one's senses unawares. If we want to soothe our audiences with a nocturne, we can only do so by relaxing our own arm-muscles and using just as much exertion of finger and hand as will convey the impetus of this tone-inducing weight to the hammer and to the string through the keys; and the bent and flat finger attitudes respectively help greatly to increase this difference in quality. The manner of tone production just described, Matthay has termed weight touch, to distinguish it from all other kinds which are started by muscular exertion. These muscular combinations are the most important of all the Matthay teachings, further details of which may be found in his own works.

Bent and Flat Finger Staccato. These different qualities of tone are equally available in staccato and in legato. When the "bent" and "flat" finger attitudes are employed for *staccato*, they show two different kinds of rebounding. The "bent" movement of the finger rebounds to the position it held before key-movement. The "flat" *continues* in the direction in which it is going, as though very quickly sliding a threepenny-piece from the keys.

Arm Position. We have spoken of the normal attitude and varying position of fingers and hands and wrists. What is the normal position of the arm? A rather outstretched one, not a right, but rather an obtuse angle. Not thus, , but rather thus, . The forearm should either be level from elbow to wrist or else dropping a little towards elbow, thus:  The elbow should hang quite free from the body and travel freely outwards (sideways) when a passage moves to the keyboard extremes.

Do not sit too near the instrument. Sit so that the arm at the elbow "is sufficiently forward of the body," and get this either as in diagram (*a*) or (*b*). If bending slightly forward, support the body well by the waist-muscles at your back, and in any case breathe fully and deeply.



Mastery of Keyboard. We have treated of the several laterally modified positions of the hand that must be assumed and retained with the greatest possible ease. Now, it is evident, as music is not made up of continuous series of scales or arpeggio, or five-finger position groups or repeated notes, or of octaves or of chords, but of endlessly varied combinations of such, that the hand must be continually varying its position laterally to the keyboard and to the forearm, and that an "oily" adaptability in this respect is indispensable for successful keyboard manipulation. *And through all these changes the hand must lie on the keyboard, hanging from your forearm, and the fingers must thus rest on the keys.* When we have tested for right muscular conditions, we must forget ourselves and our muscles, and give all our attention to the instrument and the music we wish to draw from it.

Technical Material. The material for the study of all these forms of mental muscular instrumental expertness may be found in any piece we practise, all the difficult passages being extracted and used as the stuff of such technics. But ample specialised material is to be found also in Schmitt's "Five Finger Exercises," Beringer's "Daily Practice," Camille Stamaty's "Le Rhythm des Doigts," Germer's "Technics," Czerny's "Virtuosen Schule," and the like, to which the student may refer if he will. We must never begin the muscular practice of such things until the mind has mastered the material, its musical shape, and keyboard contour. Theoretical study, the study of harmony, of chords, passing notes, of form, etc., are necessary for this, as without such study the mind has to burden itself with too much detail.

But besides such scrappy technics as have been alluded to, it is well to work at some larger forms, so-called Studies, in which the constant repetition of some technical difficulty given in a particular figure is made pleasing and musical by the form in which it is presented. Such are helpful in the matter of endurance. For the study of finger facility, nothing better, probably, will ever be written than Czerny's Etudes, which are calculated to prevent the formation of such bad habits, such hindrances to good results of any kind, as *key-bed squeezing* and the use of *down-arm force.* As agility passages can only be played successfully when there is no "jamming" of the key upon the bottom of the key-bed, such studies, properly practised, and the study of staccato, form the best tests and preventatives against such harmful and unnecessary attempts to push the piano through the floor.

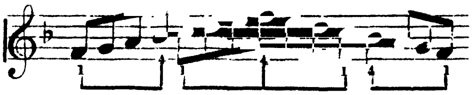
In Czerny we find an abundance of delightful running passages with staccato single notes or chord accompaniments, and with every now and then detached *ff* chords on which to try the full weight of our suddenly released arm. For, of course, during all these dainty running passages we have been supporting the weight of the arms with their own "up" muscles; and not only is it delightful now and then to be allowed to relax thus for a moment, but it is essential for us as artists to understand and swiftly bring about such successions of totally opposite muscular conditions as produce such totally opposite instrumental results. Light agility passages also, needless to say, strengthen the arms, since they give them so much work in keeping their own weight off the keyboard. Czerny's "Velocity Studies," "Staccato and Legato," and "Finger-fertigkeit" can be recommended.

Fingering. And now as to fingering. This must be derived not merely from the contiguity of the notes, but also and chiefly from the meaning of the music—its phrasing. Still, there are general rules of fingering which we must make into habits—rules which are broken whenever the phrasing demands it. These rules are: (i) Contiguous fingers on contiguous ivories. (ii) When ebonies are mixed with ivories it is easier, as a rule, and therefore advisable, to leave the black keys to the four fingers, and to use thumb on white keys by preference. Many modern advanced players, *for the sake of practice*, take all the five-finger exercises and scales in all keys with the same fingering, using thumb on black keys and white alike. (iii) Groups larger than five contiguous keys are reached in different ways, thus: (*a*) by extension, (*b*) by contraction. Or (iv) we get along the keyboard by connecting such fingering group units by passing the thumb under fingers or fingers over thumb. The thumb, which was in former times entirely neglected, is used as a pivot for fresh finger-groups, and connects them by passing under the other four fingers, or letting them swing over it as it gently rests on its key. We shall notice now that all scales consist of two such united finger-groups, these two sufficing for each octave.

Scale Fingering. Normal scale fingering we have already learnt. All the major scales with sharps are fingered like the scale of C, with the exception of those scales that make use of all five black keys; the latter are B, F♯ and C♯. These "all-black" keys make use of only two white keys. The thumb is used twice in each octave—we must use it on the two white keys—and this settles for us the position of the two finger-groups. The black keys are grouped in ▌▌ and ▌▌▌. Be prepared to use over them either two fingers or three, thus: ▌▌ $\substack{2\ 3\\3\ 2}$ or ▌▌▌ $\substack{2\ 3\ 4\\4\ 3\ 2}$. The flat scales in right hand are fingered with thumbs falling always on the white C's and F's. In the left hand the fingering of flat scales is easy. Till you reach the all-black key G♭, they all begin with the middle finger, and turn the fourth finger over the thumb to the new flat (the flat just added for this particular scale). The old-fashioned fingering of F left hand was 5 4 3 2 1 3 2 1, but it is now permitted to finger this *regularly*—*i.e.*, like the other flat scales, thus: 3 2 1 4 3 2 1.

The tonic minors of sharp scales are fingered like the majors, with the following exceptions: In the right hand F♯ and C♯ minor harmonic and melodic; in the left hand A♭ minor melodic and E♭ minor harmonic and melodic. The fingering of these is given below.

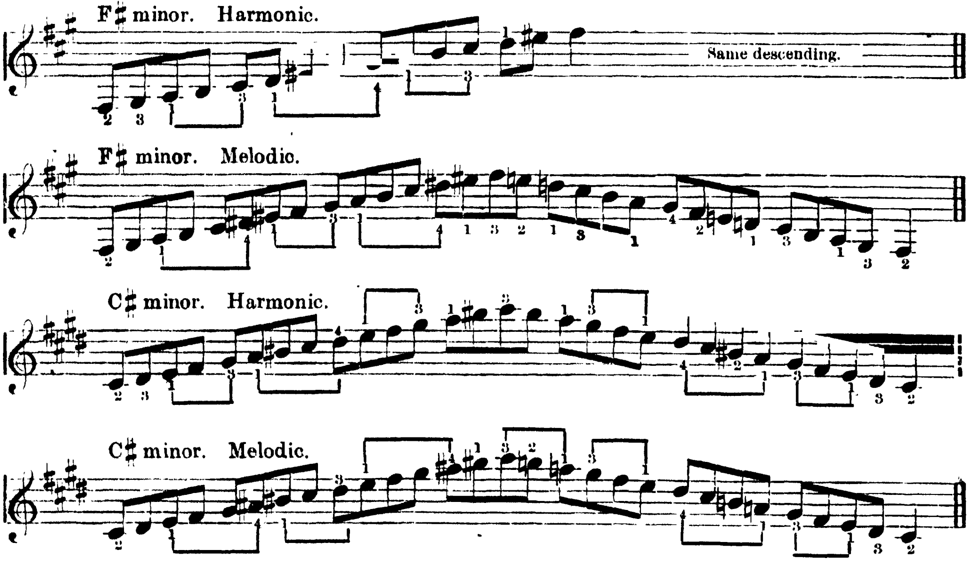
General Principles of Scale Fingering. The only way really to grasp the general principles of scale fingering is to notice that (*a*) there are seven notes to the scale and that we have four available fingers, the fifth being used only at a terminal or at a returning point; (*b*) that we cover the seven notes with these two finger groups 1 2 3 4 1 2 3—that the fourth is used only once in each octave, except when used as a terminal finger, thus:



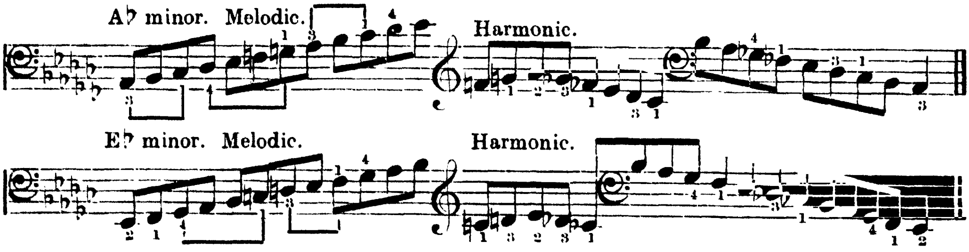
and (*c*) that the arrangement of these finger-groups (the notes on which these two groups shall be placed) depends primarily on our habit of using the thumb on the ivories rather than on the ebonies, and arranging the "turn over" of the fingers over the thumb to occur *to* a black key.

Continued

IRREGULAR FINGERING OF MINOR SCALES—RIGHT HAND



IRREGULAR FINGERING OF MINOR SCALES—LEFT HAND



The brackets show the finger-groupings

continued from page 1494

THE FOOD OF ANIMALS

Omnivorous, Herbivorous, and Carnivorous Animals. Their Principal Characteristics. The Modification of Functional Organs to Environment

By Professor J. R. AINSWORTH DAVIS

In the earlier part of the Tertiary epoch [see Geology] extensive tracts of marshy ground covered considerable areas in the land-masses occupying the northern hemisphere, and here dwelt a large number of primitive mammals, the ancestors of forms which are now more highly specialised. These creatures were not of large size, and they lived for the most part on vegetable matter, which they chewed up with their relatively numerous (44 in all) and comparatively simple teeth, the crowns of the rather small grinders being provided with crushing tubercles. There were five digits in each extremity, and locomotion was effected in a *plantigrade* manner—*i.e.*, on the palms of the hands and the soles of the feet.

Adaptation of Mammals to Natural Surroundings. The swamps just described were to a large extent superseded as time went on by extensive plains, covered with grass and other forms of vegetation. These altered conditions led to the evolution from the primitive swamp-dwellers of Hoofed Mammals (*Ungulata*) and related forms, suited for comparatively rapid progression on the plains, and adapted to feed on their abundant vegetation, which was drier, and therefore more difficult to chew and digest than the succulent plants of the marshes and damp forests.

That the hoofed mammals should become more speedy than their ancestors is intelligible when we remember that the Flesh-eaters (*Carnivora*) began to evolve from the same stock at the same time. The struggle for existence is, and has always been, so keen that no sources of food-supply remain neglected, and while some forms have turned their attention to plants, other forms have preyed upon the plant-eaters. The mechanisms concerned with rapid progression are dealt with later. It will be well to remember that hoofed mammals include *odd-toed* forms (tapir, rhinoceros, horse), and *even-toed* forms (pig, hippopotamus, ruminants), while elephants and sea-cows constitute two related orders. Gnawers (*Rodentia*), Monkeys and Men (*Primates*), some Mammals Poor in Teeth (*Edentata*), and some Pouched Mammals (*Marsupialia*) also demand attention.

Let us take first the odd-toed hoofed mammals. The tapirs, which superficially resemble pigs, are a somewhat primitive waning group, now only found in the Malay region and parts of South and Central America. They still largely adhere to the old swamp life, but are to some extent specialised, their snouts being drawn out into a short proboscis, and their grinding teeth ridged, an improvement upon projecting tubercles.

The Horn's Twofold Use. The rhinoceroses [233, page 1490] of Africa and South Asia are a step in advance of the tapirs, their teeth being more or less reduced in number, and the crowns of the large grinders having a more complex set of ridges, converting them into a very efficient masticatory apparatus. One or two horns—in the latter case one behind the other—are borne on the snout, and are said to be used for grubbing up vegetable food. Their large size, enormous strength, formidable horns, and thick skins, also render these creatures practically immune from the attacks of the flesh-eaters.

Horses, asses, zebras, and quaggas are remarkable for their speed (the ass must not be judged in this respect from the familiar "moke") and gregarious habits, which go far to protect them from enemies. Their teeth show increased complication, the grinders possessing elaborately ridged crowns, and, being composed of three materials of different degrees of hardness, always keeping rough—a great point when somewhat dry vegetable food has to be chewed. Canine teeth are practically absent, though often feebly represented in the stallion, and the front teeth (incisors) are provided with deep pits, which get filled up with masticated food, resulting in a black "mark" on the crown, which is a practical guide to age.

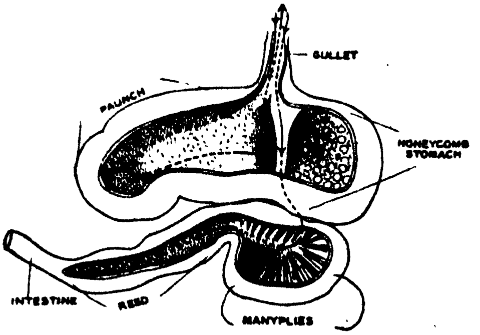
The Large Family of Pigs. Consider now the even-toed hoofed mammals. The widely-distributed swine — represented in America by the peccaries — are, in some respects, the most primitive members of their order, as shown by their fondness for marshy ground (even the domesticated form "wallows in the mire"), their full number of teeth, and the tubercles on the crowns of the grinders. They are of omnivorous habits.

The well-known hippopotamus [234] of Africa (there is also a small species in Liberia) is practically a huge pig, which spends most of its time in rivers, and is a vegetarian pure and simple. But its dentition is somewhat specialised. The pig is familiarly associated with Ireland, as being the "gintleman that pays the rint," and it is interesting to observe that the ridges on a worn grinder of the hippopotamus are arranged in a sort of double-shamrock pattern.

Chewing the Cud. Ruminants (*Cud-chewers*), a group of the even-toed hoofed mammals, include deer, oxen, sheep, goats, antelopes, giraffes [235], and camels, with their allies. Rumination, or "chewing the cud," is a somewhat peculiar digestive process, which in effect means the power of swallowing a hasty meal, retiring to a place of safety, and then bringing back the said meal in successive portions ("boluses") to the mouth, to be carefully chewed, swallowed, and digested. This arrangement is associated with a complicated four-chambered stomach [**242**] (portions of which are familiar to eaters of "tripe"), consisting of (*a*) the paunch (*rumen*), (*b*) honeycomb stomach (*reticulum*), (*c*) manyplies (*omasum*), and (*d*) reed (*abomasum*). The food is first hastily cropped, without chewing, and passes into the paunch, from which it goes into the honeycomb stomach. Here it is made up into rounded boluses, and returned into the mouth. After careful chewing, it is once more swallowed, and now enters the manyplies, which has numerous leaf-like folds, and serves as a strainer. Thence it passes to the reed, where it is subjected to the chemical action of the gastric juice, and ultimately reaches the intestine, there to be further digested and absorbed.

In all ruminants, except camels, and the related llamas and alpacas of South America, the upper teeth (including the canines) have disappeared. In the ox, for example [**243**], the lower front teeth bite against a horny pad on the upper jaw, and it may be added that the grinders possess flat crowns with a fairly complex arrangement of ridges, making them efficient millstones.

Distinctive Features of the Elephant. ELEPHANTS (*Proboscidea*) which inhabit Africa and South Asia are well defended herbivores, that are in some respects primitive in structure, though their teeth and trunk are remarkably specialised [**236**]. There are no front teeth, except two upper incisors, which are elongated into formidable tusks, serviceable as defensive weapons, and also employed for grubbing up succulent roots. The huge and complicated grinders succeed one another from behind forwards, instead of from below upwards, as in other cases. In an adult animal, only four of them are in place at the same time. The crowns of these great teeth possess a series of lozenge-shaped ridges in the African elephant, and more numerous narrow transverse ridges in his Indian cousin.



242. STOMACH OF AN OX (cut open)
Course of food shown by arrows

The trunk of an elephant, which is no more than a nose drawn out into a complex and delicate manipulatory organ, largely compensates for huge bulk and strong pillar-like legs, which serve simply as organs of support. By its means tree-branches on the one hand, and herbage on the other, are easily secured as food.

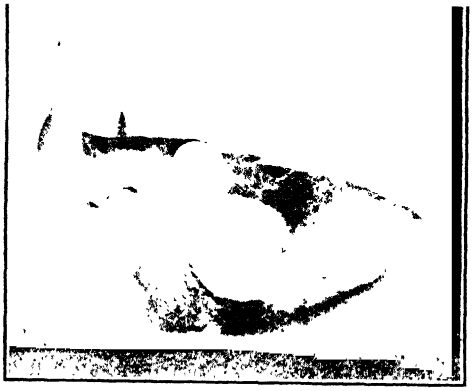
SEA-COWS (*Sirenia*) are related to the elephant order. The dugong and manatee, mentioned already in this course, are probably to be regarded as an ancient offshoot from the ungulate stock, which have become adapted to a vegetarian aquatic life, have lost their hind limbs, and simplified their teeth. A gigantic toothless member of the order (*Rhytina*) formerly lived on the islands of the Behring Sea, and only became extinct, through the agency of man, in the eighteenth century. In certain fossil forms the remains of the hind limbs are better developed than in existing types.

Specialised Teeth of Gnawers. The large order of GNAWERS (*Rodentia*) consists of mostly small and comparatively simply organised mammals, found in nearly all parts of the world, though their headquarters are in South America. Forms familiar in Britain are rabbit, hare, squirrel, rat, and mouse. Taking the rabbit [**244**] as a type, we shall find two chisel-edged incisors above and below, no canines, and a number of prismatic grinding-teeth with transversely ridged crowns. All of them grow continuously throughout life. The incisors remain sharp because they are thickly coated in front with relatively hard enamel, the rest of them being mostly made up of dentine or ivory, which is not so hard. Hence they wear unequally, and maintain a sharp edge. As the teeth are constantly growing, constant gnawing is necessary to keep them worn down, and if an unfortunate animal happens to lose an incisor, the one which normally should bite against it grows to an inordinate length, and ultimately causes the death of its unfortunate possessor.

Tree-dwellers. Squirrels are interesting because they have become adapted to an arboreal life. Their long bushy tails serve as balancing organs. The water-rat and its smaller relatives (voles) possess comparatively complex grinding-teeth. Rats and mice are distinguished by their omnivorous habits, and are to be found in almost all parts of the world. Of non-British members of the order, beavers, porcupines, capybaras, and chinchillas may be mentioned. Beavers, as is well known, are able to fell trees with their gnawing front teeth, and in this way are able to construct dams across rivers, on the upper side of which they construct rounded "lodges," sunk beneath the surface and entered by an opening that has to be reached by diving.

The ground porcupines of the Old World, and the climbing porcupines of the New, possess defensive quills which serve as an effectual protection against most enemies, and are in reality modified hairs of large size. The capybara, a native of South America, is the largest existing rodent, being about as big as a medium-sized pig. Its molars are large and complicated, and it is of aquatic habit. The little chinchillas of the high Andes are noted for the soft fur which they yield.

Monkeys. Arboreal forms are MONKEYS (*Primates*), native to the warmer parts of both hemispheres, and of predominatingly vegetarian habit, though some of them (and man) are omnivorous. As compared with more typical mammals, the teeth are somewhat reduced in number (32 in all), and the crowns of the grinders are tuberculated. In some of the leaf-eating monkeys the stomach is of complicated nature, as this kind of food is rather difficult to digest



243. SKULL OF AN OX
(Photographed by Prof. B. H. Bentley)

Mammals Poor in Teeth. An ancient order are MAMMALS POOR IN TEETH (*Edentata*), now on the down grade. The sloths of South America are arboreal leaf-eating forms, which hang head downwards from tree branches by means of their long hook-like claws. In comparatively recent geological times huge ground-sloths lived in South America, which were too big to climb trees, but were strong enough to uproot them in order to feed upon their foliage.

In the primitive order of POUCHED MAMMALS (*Marsupialia*) there is not a regular succession of two sets of teeth, as in higher mammals, and only the first grinder appears to have a regular successor. The arboreal opossums of America are omnivorous, and a number of the Australian members of the order are pronounced vegetarians. The springing kangaroos [**240**, page 1493] and their allies browse upon grasses and herbs; the wombats burrow, and gnaw roots by means of their rodent-like incisors; tree-kangaroos and phalangers are arboreal, and the latter live largely upon fruit. The little mouse-phalangers possess long, slender tongues, which they insert into flowers to secure nectar, and probably small insects as well.

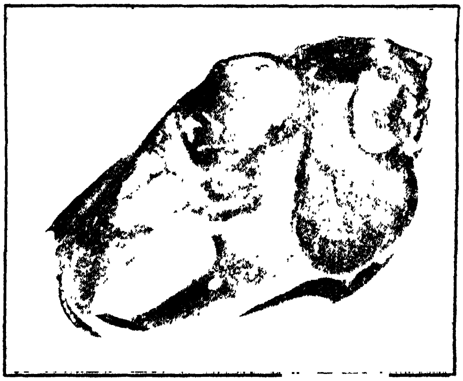
Carnivorous Mammals. There are five orders, all or most of the members of which live upon animal food—*i.e.*, Insect-eaters (*Insectivora*), Bats (*Chiroptera*), Whales and Porpoises (*Cetacea*), Flesh-eaters (*Carnivora*), and Egg-laying Mammals (*Monotremata*). Carnivorous forms are also to be found among the Mammals Poor in Teeth (*Edentata*), and the Pouched Mammals (*Marsupialia*).

Insect-eaters. Some of the small nocturnal animals which make up the order of INSECT-EATERS are to be found in almost all parts of the world except South America and Australia. They may be said to play much the same part in regard to the minor varieties of animal food that gnawers do with reference to vegetable food, and, like them, are of simple organisation.

The familiar European Hedgehog (*Erinaceus europæus*) is a good type of a group of the order which is pretty common in the Old World, and has allies in the West Indies [**231**]. In accordance with the nature of its food, which mostly consists of worms, snails, insects, and other small creatures, the teeth of the hedgehog are sharply pointed, those at the back having their crowns provided with small cutting projections. Such teeth are eminently suitable for dealing with the small animals named, as well as with snakes and other reptiles, frogs, and even mice, none of which are despised as articles of diet.

The name "hedgehog" has been suggested by the shape of the snout, which is something like that of the pig, and used in much the same way for grubbing in the ground.

The Smallest Mammal. Shrews are very small, mouse-like creatures, having a very wide distribution. There are three species native to Britain, two of which are our smallest mammals, while the group is notable for the fact that some of its members are more diminutive than any existing mammals whatsoever. A body less than an inch and a half in length, plus an inch-long tail, is about the record. The teeth of a shrew are much like those of a hedgehog, but its snout is much more slender. Jumping shrews, little desert animals, are native to Africa, and are adapted for springing, their hind legs being much elongated.



244. SKULL OF RABBIT
(Photographed by Prof. B. H. Bentley)

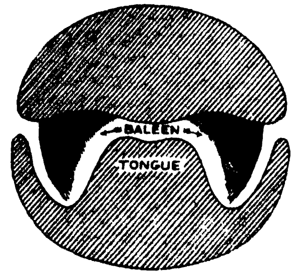
While the insect-eaters so far named hunt for their food on the ground (except water-shrews), there are tree-shrews that are arboreal. In appearance they somewhat resemble squirrels, and are native to S.E. Asia.

Among aquatic insect-eaters, the desmans inhabit some of the rivers of the Old World—*e.g.*, the Volga, and are larger than the average of their kind. The snout is drawn out into a short proboscis, well adapted for searching out food in the crannies of river banks. In West Africa, an animal (*Potamogale*) has been found in some of the rivers which might easily be mistaken for a small otter, but is really a member of the present order. The resemblance has been brought about by adaptation to a similar mode of life.

A Hungry Underground Hunter. The well-known Mole (*Talpa Europœa*) is beautifully specialised for the pursuit of earthworms and other small animals underground, and is one of the hungriest and most untiring of hunters, far excelling lions and tigers in these respects. It belongs to a group which is characteristic of the north temperate zone, and has allies (golden moles) in Africa.

The members of the ancient and almost ubiquitous order of insectivora have become adapted to the pursuit of small prey on the ground, in fresh water, among trees, and in the earth. The closely related BATS (*Chiroptera*) have acquired the power of flight, and wage incessant warfare in the air against such members of the insect tribe as come out at dusk [232]. That part of the flying membrane which stretches between the hind limbs and tail can be turned forwards and used as a kind of sweep-net, which proves very effective. Bats are found all over the world.

There can be no doubt that WHALES AND PORPOISES (*Cetacea*) have descended from terrestrial ancestors, but their exact line of descent is somewhat doubtful. Some members of the order possess numerous sharp simple teeth, which are eminently suitable for seizing and holding slippery fishes and cuttle-fishes. The common porpoise (*Phocæna communis*) is one of the most familiar forms ; indeed, too familiar, for it is a great enemy of the fisherman, not only on account of its appetite, but because it damages his nets and frightens away his lawful booty.



245. SECTION OF WHALE'S HEAD

The huge sperm whale, or Cachalot (*Physeter*), is an example of a toothed cetacean on a large scale.

The Source of Whalebone. The whalebone whales, which include the monsters of the order—up to 85 feet—have no functional teeth, though in very early life these are to be found embedded in the gums, which, however, they never cut. The most noteworthy peculiarity of these forms, as seen familiarly in the Greenland whale (*Balæna mysticetus*), consists in the presence of numerous pairs of horny plates (*baleen*), frayed out at the edges, which hang down from the roof of the mouth [245]. The so-called "whalebone" is derived from them. The whales of this group feed upon the small animals which float in enormous numbers at or near the surface of the sea, making up what is technically called "plankton." Moving along at some speed, the whale takes in large quantities of sea-water, which is strained through the baleen, leaving behind in the mouth the numerous small creatures it contains. The danger of choking during this process of feeding is obviated by the fact that the top of the windpipe is drawn out into a cone, which fits into the back of the nasal passages in such a way that no water can possibly find its way into the lungs.

FLESH-EATERS (*Carnivora*) are descended from the same ancient swamp-dwelling stock as hoofed mammals, but claws have been evolved instead of hoofs, and the teeth are more or less suited to flesh-eating. Seals, sea-lions, and walruses, have become adapted to an aquatic life.

Bears (*Ursidœ*), with the exception of the Polar bear (*Ursus maritimus*), are of omnivorous habit [238], and though the canine teeth are in the form of prominent tusks, the back grinders have blunt crowns, suitable for dealing with a miscellaneous diet. These creatures exhibit the primitive character of being plantigrade.

The remaining land carnivores are typically *digitigrade—i.e.*, they walk on the ends of the fingers and toes, and their back teeth are mostly compressed, and possess cutting crowns.

The omnivorous badger (*Melus tarus*) and its immediate allies are the least specialised members of the group, and in many respects resemble bears in structure. But weasels, stoats, sables, martens, and the like, are eminently carnivorous and bloodthirsty. None of them are of any great size, and the narrow, short-legged body is well suited for penetrating undergrowth. Some are arboreal, and the weasel makes its way underground to attack burrowing mammals, such as moles and field-voles. The otter (*Lutra vulgaris*) is a predaceous aquatic member of the group, with sharp-pointed teeth, adapted for seizing fish. In the rare sea-otter (*Enhydris*) of the North Pacific the back teeth have blunt crowns, in accordance with the diet, which consists mainly of sea-urchins, crabs, and shell-fish, all of which need to be crushed.

The small animals of the Raccoon and Coati Family (*Procyonidœ*) are nearly all American, and the best-known forms are the raccoon (*Procyon*) and the coati (*Nasua*). The former lives a good deal among trees, but also hunts for prey in brooks. It is remarkable for the curious habit of washing its food. The long-snouted coati is largely arboreal, and hunts down tree-lizards, but it also frequently descends to the ground for the purpose of grubbing up worms and other small creatures with its snout.

The Dog Family. The members of the Dog and Wolf Family (*Canidæ*), including jackals and foxes, are very widely distributed, there even being a sort of dog—the dingo—in Australia. These creatures are more specialised than bears, but less so than the cats and their allies. Wolves and wild dogs hunt in packs, and track their quarry by smell.

The family of Civet-cats and Mungooses (*Viverridæ*) includes a large number of small animals, which are well adapted to a carnivorous life, but not so highly specialised as the cats proper. The civet-cats (*Viverra*) are nearly all ground animals, mostly from South Asia, but also represented in Africa, to which continent their relatives, the genets (*Genetta*), are almost entirely confined. The Indian palm-civets (*Paradoxurus*) live in trees, and not only prey upon various small animals, but also eat fruit to some extent. The mungooses (*Herpestes*) are small African and South Asiatic animals, somewhat resembling stoutly-built weasels, and remarkable for their extreme agility, which enables them to cope successfully with poisonous snakes.

The comparatively large Hyænas (*Hyænidæ*), closely related to the civet-cats, etc., feed mostly upon carrion. The striped hyæna (*Hyæna striata*) of Asia and Africa, and the spotted hyæna of South Africa (*Crocuta maculata*), have immensely powerful jaws and teeth, with which they can easily crunch up bones. The aardwolf (*Proteles*) of South Africa is a kind of degenerate hyæna, with reduced and comparatively feeble back teeth. It burrows underground, and devours termites (white ants) as well as carrion.

The Cat Family. The Cat Family (*Felidæ*) includes the beasts of prey *par excellence*, such as the lion [**237**], tiger, leopard, and cheetah of the Old World, and the puma and jaguar of the New. The domestic and other "cats" also belong here. Examination of the skull of a lion will show some of the specialisations that exist in connection with the carnivorous habit. The jaws are of enormous strength, and the prominent ridges on the skull are partly for the attachment of muscles that work the lower jaw up and down. The canine teeth are exceedingly powerful tusks, used in seizing prey, while the crowns of the back teeth are cutting blades of great efficiency.

As is familiarly known, the claws of cat-like animals are employed against their victims with deadly effect, and when not in use are drawn back into sheaths, and thus prevented from becoming blunt. They are sharpened by being rubbed against trees. Sight and hearing are very acute in members of the group, all of which stalk their prey, finally securing it by a sudden rush or spring.

Of the three families belonging to the subdivision of Aquatic Carnivores (*Pinnipedia*), one includes the walrus (*Trichechus*), which has enormous tusk-like upper canines, and grinders with blunt crowns. The former are used for grubbing up shellfish as food from the sea-bottom, and the latter for crushing them. The sea-lions and seals, which make up the two other families, are fish-eaters, and the crowns of their back teeth are laterally flattened and sharply pointed. In all these aquatic forms the limbs are in the form of paddles.

Among EGG-LAYING MAMMALS (*Monotremata*) the spiny ant-eater (*Echidna*) and duck-billed platypus (*Ornithorhynchus*) are both carnivorous. The former [**239**, page 1493] possesses a narrow, toothless snout, and its long, sticky tongue secures insect prey. The duck-billed platypus [**241**, page 1494] lives in streams, feeding largely on water-snails, which it is able to crush by means of horny plates in its jaws.

MAMMALS POOR IN TEETH (*Edentata*) include the great ant-eater (*Myrmecophaga*), adapted to feeding on insects, much in the same way as the spiny ant-eater. With its enormous claws it is able to tear open ant-hills in pursuit of its prey. The Cape ant-eater, or aardvark (*Orycteropus*) of South Africa (which possesses back teeth), and the scaly pangolins (*Manis*) of Africa and South Asia, are both specialised in a similar fashion.

Among the Australian members of the POUCHED MAMMALS (*Marsupialia*) order we find carnivorous forms which superficially resemble species belonging to various other orders, the resemblance having been brought about by adaptation to similar modes of life. Such are the native "wolf" (*Thylacinus*) of Tasmania, the dasyures (resembling civet-cats), the banded ant-eater (*Myrmecobius*) (which, however, possesses unusually numerous teeth), and the pouched mole (*Notoryctes*).

Continued

Continued from page 1623

LATIN—ENGLISH—FRENCH—GERMAN

Latin and English by G. K. Hibbert, M.A.; French by Louis A. Barbé, B.A.; German by P. G. Konody and Dr. Osten

LATIN

Continued from page 1617

By Gerald K. Hibbert, M.A.

LATIN VERSE

IN the first lesson it was mentioned that some syllables were short and others long—*e.g.*, **mensă** (nom.), **mensā** (abl.). These syllables are said to differ in quantity. We have now to consider *prosody*, that part of grammar which deals with the quantity of syllables and the laws of metre.

I. QUANTITY OF SYLLABLES

General rules of quantity:

1. Every diphthong and contracted syllable is long: *Mensæ*, *cōgo* (*co-ago*).

2. A vowel coming immediately before another vowel is short: *Pĭus*, *prŏhibe* (h is not taken into account in prosody, being regarded as a breathing only). There are some exceptions—*Ænēas*, *dīi*, *Pompēi*, *fīo* (but *fieri*).

3. Any vowel followed by two or more consonants, or followed in the same word by *j*, *x*, or *z*, becomes long by position—*adēstis*, *āxis*.

Note. The two consonants need not be in the same word. Thus, in *jacēt corpus* the *e* is long by position before *t* and *c*, though had the second word begun with a vowel, the final syllable of *jacet* would have been short.

4. A vowel followed by a mute consonant with a liquid after it is doubtful—*e.g.*, either *lugŭbre* or *lugūbre*. But *gn* always makes a long syllable, as *īgnis*, *āgnus*.

On the Quantity of Final Syllables.

1. Most words of one syllable are long, as *mē*, *vīs*. Exceptions: Words ending in *l*, *b*, *d*, *t*, as *vĕl*, *sŭb*, *ĭd*, *ĕt*. Also *ĕs* and its compounds, *adĕs*; *quĕ*, *vĕ*, *nĕ* (enclitic—*i.e.*, joined to a word—as *amasnĕ* = dost thou love; but *nē* = lest, is long); *nĕc*, *ăn*, *ĭn*, *pĕr*, *tĕr*, *cŏr*, *ŏs* (*ossis*), *făc*, and *fĕr* (imperatives of *facio* and *fero*), *bĭs*, *ĭs*, *cĭs*, *quĭs*.

2. Words ending in *a* are long—*contrā*, *frustrā*, *amā*. Exceptions: Accusative and nominative cases, and *ită* and *quiă*. (All ablatives in *a* are long.)

3. *e* final is short—*regĕ*, *regitĕ*, *ferrĕ*. Exceptions: Cases of 1st and 5th declensions, as *diē*, *Cybelē*; imperative sing. of 2nd conjugation, as *monē*: *quarē*, *hodiē*, and adverbs derived from adjectives, as *dignē*.

4. *i* final is long—*abī*, *plebī*. Exceptions: *Sicubĭ*, *necubĭ*, *nisĭ*, *quasĭ*; also Greek vocatives and datives, as *Chlorĭ*. But *mihi*, *tibi*, *sibi*, *ubi*, *ibi*, are doubtful.

5. *o* final is long—*virgō*, *amō*, *dominō*. Exceptions: *Citŏ*, *modŏ*, *egŏ*, *duŏ*, *octŏ*, *sciŏ*, *nesciŏ*.

6. *u* final is long—*tū*, *diū*, *rectū*.

7. *y* final is short—*chely̆*, *Tiphy̆*.

8. Words ending in *c* have their last syllable long (*illūc*), except *donĕc*.

9. Words ending in *l*, *d*, *t* have their last syllable short—*animăl*, *illŭd*, *jacĕt*.

10. *n* final is short—*nomĕn*. Exceptions: Many Greek words—*Hymēn*, *Ammōn*.

11. *r* final is short—*calcăr*, *amatŭr*. Exceptions: Many Greek words *cratēr*, *aēr*.

12. Words ending in *as* are long—*mensās*, *amās*. Except *anăs* duck, and Greek cases of 3rd declension, as *lampadăs*, *Arcăs*.

13. Words ending in *es* are long—*sedēs*, *amarēs*. Exceptions: *Penĕs*; a few nouns like *segĕs*, *mergĕs*, and Greek plurals like *Troadĕs*.

14. Final *is* is short—*regĭs*, *similĭs*. Exceptions: Dat. and abl. plural, *mensīs*; 2nd sing. pres. indic. of 4th conjugation, *audīs*; compounds of *vīs* and *sīs*, *malīs*, *nolīs*, *velīs*, *gratīs*, *forīs*.

15. Final *os* is long—*dominōs*, *sacerdōs*. Exceptions: A few Greek words, as *epŏs*.

16. Final *us* is short—*opŭs*, *amamŭs*. Exceptions: 4th declension contracted cases, *gradūs* (gen. sing., nom. voc. acc. pl.); words whose genitive increases and has the last syllable but one long, as *tellūs*, *incūs*, *juventūs*, *virtūs*.

17. *ys* final is short—*chelys*.

Note. Remember that all naturally short final syllables are liable to become long by position; see above, Rule 3 under general rules of quantity. Thus, the *us* of *opŭs* would become long if the word following began with a consonant, because the *u* would then precede two consonants.

II. LAWS OF METRE

Each of the following combinations of syllables is called a *Foot*:

A long syllable following a short one (˘¯) forms a foot called the *Iambus* ("satirical," because first used in satire).

A short syllable following a long one (¯˘) forms a foot called the *Trochee* ("running" or "tripping").

Two long syllables (¯¯) form a *Spondee* (so called because much used in the solemn hymns sung at a *Spondē* or drink-offering).

A long syllable and two short ones (¯˘˘) form a *Dactyl* ("a finger," from its resemblance to the joints of the finger).

Three short syllables (˘˘˘) form a *Tribrach*.

Two short syllables and a long one (˘˘¯) form an *Anapæst* ("reversed," because it is a dactyl reversed).

Scansion. Scansion is the art of counting and measuring the feet in a line or verse; when we mark off a verse into the feet which compose it we are said to scan it (*lit.* "to climb" it).

When a word ending in a vowel is followed by a word beginning with a vowel, the first vowel is dropped, or elided. This is called *Elision* or *Synalepha* ("melting together")—*e.g.*, *qui adverso* would be scanned *quād|vērsō*, the down-stroke marking the end of a foot.

When a word ends in *-m* preceded by a vowel, and the following word begins with a vowel, the vowel and *-m* in the first word are dropped. This is called *Ecthlipsis*—*e.g.*, *quantum est in rebus inane* would be scanned *quānt|ēst īn rēbŭs īn|ānē*; and *telum hæc* would be scanned *tēl|aēc* [see translation of "The Lost Leader" further on].

Metres. The two commonest metres in Latin are (1) Hexameter, in which each line consists of six feet, and (2) Elegiac, in which a Hexameter line and a Pentameter (five feet) alternate. All Virgil's works are written in the former, while Ovid, Tibullus, and Propertius are the chief Elegiac poets. The only feet used in these metres are Spondee and Dactyl.

1. **Hexameter.** The first four feet may be Dactyls or Spondees; the fifth must be a Dactyl; the sixth a Spondee. Thus the scheme is:

1.	2.	3.	4.	5	6.
⏑ ⏑	– ⏑ ⏑	– ⏑ ⏑	– ⏑ ⏑	– ⏑ ⏑	– –
	– –	– –	– –	– ⏑ ⏑	–

Examples:

Quādrŭpĕ|dāntĕ pŭt|rēm || sŏnĭ|tū quătĭt | ūngŭlă | cāmpūm

Ārmă vĭ|rūmquĕ că|nō || Trō|jæ quī | prīmŭs ăb | ōrīs.

A break in the words, called *Cæsura*, is usually made after the first syllable of the third foot; that is, a word usually ends with that syllable. The Cæsura is marked by the double line ||. This is called a strong Cæsura, but if the break occurs after the second syllable of a Dactyl (as *Nōn ōm|nēs ăr|būstă || jŭ|vānt hŭmĭ|lēsquĕ mȳ|rīcāē*), it is called a weak Cæsura.

A Hexameter must end either with a word of two syllables or of three, as "mȳricæ." It must not end with two dissyllables, nor should there be an elision between the fifth and sixth feet.

2. **Pentameter.** This line consists of two parts, called Penthemimers; the first Penthemimer contains two feet (Dactyls or Spondees) and a long syllable. The second also contains two feet—which, however, must be Dactyls—and a long syllable.

1.	2.			3.	4.	
– ⏑ ⏑	– ⏑ ⏑	–	||	⏑ ⏑	– ⏑ ⏑	–
– –	– –					

It thus consists of two halves of 2½ feet each.

Examples.

Tū cĭtĭ|ūs vĕnĭ|ās || pōrt|ŭs ĕt āră tŭ|īs.
Lāēr|tēsquĕ sĕn|ēx || Tēlĕmăc hūsquĕ pŭ|ēr

This verse is never used alone, but always follows a Hexameter in Elegiac verse, Hexameter and Pentameter alternating.

A Pentameter must always end with a word of two syllables, though sometimes *es* or *est* closes a line, the preceding vowel or *m* being cut off. The preceding word must then be a dissyllable, as *tuum est*. The last word of a Pentameter must be a substantive or a verb, or some case of *meus*, *tuus*, *suus*.

How to make Latin Verses. Having learnt the above rules of Prosody well, and being able to scan verses, the pupil will now be able to practise turning English poetry into Latin verse. The quantity of all doubtful syllables is marked in all good dictionaries (*e.g.*, săgitta), but the pupil must determine the quantity of the others by his prosody—*e.g.*, the final *a* of *sagitta* will be long or short according to whether it is ablative or nominative. A great deal of twisting and contriving will be necessary at first, but gradually it will become easier to make the verses, and often at first sight it will be evident how the line can be made to run nicely. Adjectives and other epithets may be freely inserted if needful, and *one* line of English poetry need not be expressed by *one* line of Latin verse.

The following rendering of Browning's "The Lost Leader," by the late Sir Richard Jebb, is a splendid example of versification; careful study of these lines will go far to show the pupil the necessary changes to make in the English before it can be put into Latin verse.

"THE LOST LEADER."

Just for a handful of silver he left us;
  Just for a riband to stick in his coat—
Found the one gift of which fortune bereft us,
  Lost all the others she lets us devote.
They, with the gold to give, doled him out silver,
  So much was theirs who so little allowed.
How all our copper had gone for his service!
  Rags—were they purple, his heart had been proud!

We that had loved him so, followed him, honoured him,
  Lived in his mild and magnificent eye,
Learned his great language, caught his clear accents,
  Made him our pattern to live and to die!
Shakespeare was of us, Milton was for us,
  Burns, Shelley, were with us—they watch from their graves!
He alone breaks from the van and the freemen,
  He alone sinks to the rear and the slaves!

We shall march prospering,—not thro' his presence;
  Songs may inspirit us,—not from his lyre;
Deeds will be done,—while he boasts his quiescence,
  Still bidding crouch whom the rest bade aspire.
Blot out his name, then—record one lost soul more,
  One task more declined, one more footpath untrod,
One more triumph for devils, and sorrow for angels,
  One wrong more to man, one more insult to God!

Life's night begins ; let him never come back to us !
  There will be doubt, hesitation, and pain,
Forced praise on our part—the glimmer of twilight,
  Never glad, confident morning again !
Best fight on well, for we taught him,—strike gallantly,
  Aim at our heart ere we pierce through his own ;
Then let him receive the new knowledge and wait us,
  Pardoned in Heaven, the first by the throne !

IN LATIN ELEGIACS

(By permission of the late Sir Richard Jebb and George Bell & Sons.)

Plus ut opum minimo, clavus sibi latior esset,
  sustinuit noster deseruisse suos.
Hoc modo quod nobis Fortuna negarat adeptus
  perdidit, ah, quicquid nos dare fata sinunt.
Quis aurum fuit, argenti pendere pusillum :
  tantula de tantis censibus ille tulit.
Hunc tenui nostrum quis non adjuverat ære ?
  nostra viro sordent : munera regis avet.
Hunc amor, obsequium, reverentia nostra colebat :
  hujus erat nobis vultus ut alma dies :
"Hic Jove digna loquens, hic veri," diximus, "auctor
  dux mihi vivendi, dux morientis erit."
Mens fuit hæc Enni, fuit hæc sapientia Nævi :
  vos piget hæc damnum, Calve, Catulle, pati.
Deserit hic solus nos libera signa sequentes :
  servorum partes transfuga solus adit.
Ferre manet nobis—non hoc tamen auspice—palmam ;
  carminibus, sed non hoc modulante, frui ;
Bella gerent alii, lætabitur ille quiescens ;
  surgere quos voluit fama, jacere volet.
Hoc quoque de fastis lacrimandum tollite nomen:
  alta miser vidit, noluit alta sequi.
Hunc quoque gaudebunt Furiæ, plorabit Olympus
  jus hominum summi fas violasse Dei.
Pergimus in tenebras : ne nos petat ille reversus,
  ad dubios referens sollicitosque pedem.
Quo valeat laudes alienis dicere malis ?
  lumen amicitiæ, quod fuit, umbra premit.
More ferox nostro telum hæc in pectora vertat,
  tela recepturus pectore nostra suo :
Tum moriens nobis prior immortalia discat,
  primus in æterno stans sine labe choro.

NOTE. In the above metre, which is by far the most common in Latin, the only feet used are Spondees and Dactyls. The other feet (Iambus, Tribrach, Anapæst, Trochee) are found in the rarer metres Iambic Trimeter or Senarius, and Iambic Dimeter : the Sapphic Stanza and the Alcaic Stanza. Models of the Sapphic and Alcaic Stanzas are found in the Odes of Horace [see any good edition of Horace's Odes, such as Page's].

Concluded

ENGLISH

Continued from page 1619

By Gerald K. Hibbert, M.A.

HISTORY OF THE ENGLISH LANGUAGE

The history of the English language is to all intents and purposes the history of the English people. As we trace the growth of the language, we trace at the same time the growth of the nation. Words are fossilised history. They speak to us of waves of conquest, of eras of strife, of the gradual victory of the arts of peace over the arts of war ; they tell us of the hopes and fears, the expectations and disappointments, the laws, customs, dress and manners of those who have gone before us. A language should be regarded with reverence : it is too precious to be trifled with or debased. Everyone who debases the meaning of a word is as much an enemy to his country as the utterer of false coin.

Certainly we who speak the English tongue have a language of which we may be proud. It is rich in associations, and a veritable storehouse of wonders. It deserves and repays careful study.

Up to about the year 450 A.D. our islands were inhabited by different Keltic races, speaking various dialects of the Keltic group of languages. These races were closely allied to the inhabitants of Gaul (as France was then called), and spoke practically the same tongue. About the beginning of the Christian Era both Britain and Gaul were conquered and overrun by the Romans, but with strikingly different results as far as language was concerned. The conquered Gauls adopted the Latin language, while Latin made singularly little impression on the Kelts of Britain, who largely retained their own dialects. The Latin language was destined, however, to have its revenge ; for the Franks and Normans, who subsequently occupied France, adopted the language of that country, and were instrumental in introducing it (in an altered form, of course) into Britain about the time of the Norman Conquest, 1066 A.D.

Keltic Words. Among the earliest elements in our language, therefore, are the old Keltic words that have survived in the struggle for existence and have come down to us through two thousand years and more. These are not many, for the language of the Britons was completely displaced by that of their Saxon conquerors.

The Keltic words consist chiefly of geographical names—*e.g.*, *Devon, Dorset, Kent, Exe ; Avon, Ouse,* and *Usk* (all three meaning water), *Trent, Dee, Don, Severn, Wight, Bute, Pen* (as in *Penrith*). Also, as we should expect, words dealing with household matters, names of implements used by serfs, etc.—as : *barrow, mattock, mop, cudgel, clout, darn, crock, kiln, gruel ;* and indirectly (through the Norman-French) words like *flasket. basket, wicket, bran, gown.* One of the Keltic dialects is still spoken in Wales.

Early Latin Words. The Romans left singularly few words as the result of their 400 or 500 years' occupation of these islands. The Latin *castra* ("a camp") is found in plenty of place-names—as: *Chester, Dorchester, Gloucester, Cirencester*; *stratum* is found in *street, Stratford*; *colonia* in *Lincoln*; and *fossa* ("a ditch") in Fossbury.

The Coming of the Anglo-Saxons. Not long after the departure of the Romans from this country, fresh conquerors descended on its defenceless shores. From about 450 to 550 A.D. a constant succession of Jutes, Saxons, and Angles streamed over from the lowland region in north-west Germany. Conquering the Keltic inhabitants, they drove them steadily northward and westward into the lowlands of Scotland, and into Cumberland, Westmorland, Wales, and Cornwall. These tribes were of Teutonic stock. As their area of conquest extended, their language naturally became more and more prevalent, until in course of time (long before the Norman Conquest) it was spoken from the Firth of Forth to the English Channel. Out of the union of the dialects spoken by these tribes, the English language sprang. Anglo-Saxon is thus the backbone of our modern English. We shall trace the development of this particular element a little later on; meanwhile, not to lose the thread of our historical sketch, we pass on to the next great event influencing alike our nation and our language.

Second Latin Influx. The introduction of Christianity brought into the language many Latin words of an ecclesiastical nature. We may call it the period of the second invasion by the Latin language. Words thus introduced are mostly the names of Church dignitaries, ceremonies, and the like. They came either directly from the Latin, or indirectly through Latin from the Greek. Examples of the latter are *bishop, presbyter, baptism, eucharist, church, monastery, monk,* and *clergy*.

The Scandinavian Element. Meanwhile, during all these centuries, the Norsemen and Danes were constantly landing on our shores, in more or less successful attempts at conquest. These were men of Scandinavian race, whose language was of the same group as English (Teutonic). Owing to their settlement here, we have many of their words in our language to-day. A number of place-names in the north and east of England are Scandinavian—*e.g.*, Grimsby, Whitby (*by* = town); Furness, Skegness (*ness* = headland); Troutbeck, Welbeck (*beck* = brook); Orkney (*ey* = island); Aira Force, Scale Force (*force* = waterfall); Thorpe, Grimsthorpe (*thorp* = village); Dingwall, Thingwall (*thing* or *ding* = place of meeting); Langwith (*with* = wood); Lowestoft (*toft* = small field).

The Norman Conquest. The Normans introduced their language (a corrupted form of Latin) when they introduced themselves. This is the third, and perhaps the most important, invasion by the Latin tongue. Norman-French became the language of the upper classes and of the Law Courts: even to-day our Sovereign uses this language when he gives his assent to, or withholds his assent from, Bills that have passed the two Houses of Parliament.* For a time, however, the mass of the English people clung tenaciously to their old language, but gradually the two races began to blend, and English assumed the form which it has to-day—a fusion of Anglo-Saxon and Norman-French. "Most of the words in our language which relate to feudal institutions, to war, law, and the chase, were introduced in this way." (Mason.) As was pointed out in the introductory article to the Study of Languages [page 117], one of the chief effects of the introduction of Norman-French was the gradual disuse of the grammatical inflexions of Anglo-Saxon. Under its influence our language has become largely analytic instead of being synthetic or inflexional.

The Revival of Learning. What is called the "Renaissance," the great revival of the study of the classical languages in the sixteenth century, gave an immense number of Latin words to our language. This is the fourth, and practically the last, invasion on the part of Latin. A perfect craze arose for using long, cumbersome, and unwieldy words taken straight from Latin, and even from Greek. The authors of this period and school are often painful reading. For example, Trench gives the following uncouth creations: "Torve and tetric = *stern, severe* (Fuller); cecity = *blindness* (Hooker); insulse = *tasteless* (Milton); facinorous = *guilty* (Donne); sufflaminate = *to put the drag on* (Barrow); moliminously = *with effort* (Cudworth); immarcescible = *unfading* (Bishop Hall); luciferously = *bringing light* (Brown)."

Many of the words thus introduced have long since perished, and during the last hundred years or so there has been a strong reaction in favour of a return to a purer Anglo-Saxon diction.

In many cases the same Latin word has given us two words in English, one coming direct from the Latin, the other through the medium of Norman-French. For example:

Latin.	*Direct from Latin.*	*Through Norman-French.*
Fragilis	fragile	frail
Ratio (-nem)	rational	reason
Potio (-nem)	potion	poison
Quietus	quiet	coy
Punctum	punctuate, etc.	point
Factum	fact	feat

Similarly, *hospital* and *hotel, blaspheme* and *blame, pauper* and *poor, redemption* and *ransom, senior* and *sir, rotund* and *round, junction* and *joint.*

Miscellaneous Words. In later times English has borrowed words from almost every language under the sun; as our borders have extended, and as our commerce has grown, so has our language become more and more cosmopolitan. Some of the chief of these sources may be mentioned:

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* The town-crier perpetuates a Norman-French word in his "O yes," which really is "Oyez," the imperative of *oyer*, to hear.

Chinese. Caddy, junk, gong, nankeen, tea.

Turkish. Bey, ottoman, sash, tulip, janissary.

Persian. Bazaar, altar, sherbet, turban, chess, dervish, hookah, lilac, musk, taffeta.

Hebrew. Sabbath, seraph, cherub, amen, leviathan, jubilee, Satan, ephod.

Arabic. Alchemy, alcohol, algebra, almanac, alembic, tariff, zenith, zero, nadir, talisman, naphtha, coffee, mosque, fakir, giraffe, harem, sultan, vizier.

Hindustani. Muslin, calico, rupee, lac, pundit, sepoy, thug, suttee, chutnee, jungle, pariah, nabob, bungalow, coolie, curry.

French. Etiquette, soirée, menu, eau-de-vie, chef, ennui, bouquet, bon-bon, trousseau, carte-de-visite, tête-à-tête.

Spanish. Alligator, armada, matador, toreador, battledore, galleon, cargo, bolero, eldorado, tornado, renegade, verandah, castanets, chocolate, don, negro, mulatto, grandee, pillion.

Italian. Banditti, maccaroni, folio, quarto, stiletto, stucco, incognito, gazette, brigand, gondola, influenza, motto, opera, concert, and nearly all the terms used in music.

Dutch. Boom, schooner, sloop, skipper, yacht, reef, skate.

Gaelic. Clan, tartan, pibroch, slogan, plaid.

Portuguese. Caste, cocoa, palaver, porcelain, marmalade, commodore, fetish.

Polynesian. Táboo, tattoo, boomerang, kangaroo, wombat, wonga-wonga.

American Indian. Squaw, wigwam, pampas, papoose, tobacco, tomahawk, maize, pemmican, potato, hammock.

Scientific words employed in botany, medicine, etc., are mostly derived from Latin or Greek.

The Five Periods of English. It is possible to trace five distinct periods or stages through which the English language has passed.

1. EARLY ANGLO-SAXON. This period extends practically up to the time of the Norman Conquest, at the close of the eleventh century. There were two main dialects of the language—the *Anglian* in the north and the *Saxon* in the south. Gradually the East Midland variety of the Anglian branch (spoken in the district round Oxford and Cambridge) spread to London, and became the parent of modern standard English.

2. LATE ANGLO-SAXON. This lasted from about 1100 A.D. to 1250 A.D. The most noticeable feature is the influence of Norman-French. The Normans would not trouble to learn the Anglo-Saxon inflexions, consequently the language began to lose its inflexions, and many of its distinctions vanished.

3. OLD ENGLISH. This lasted from about 1250 to 1350 A.D. The weakening influence of Norman-French was still more pronounced, and the language became rapidly analytic. The English of these first three periods is very different from that of to-day, and needs to be studied almost as though it were a foreign tongue.

4. MIDDLE ENGLISH. But when we come to this period (1350-1500), of which Chaucer is the shining light, we approach much nearer to our modern language. A great deal of Chaucer can be read right off by any English-speaking person of average education. It was during this period that the East Midland dialect became predominant.

5. MODERN ENGLISH. 1500 to the present day. This brief review helps us to see that the two chief elements in the English language are Anglo-Saxon and Latin, or (as we may also call them) the Teutonic element and the Romance element. The former was introduced into this country by the Angles and Saxons, and to a less degree by the Danes and Norsemen; the latter came in, as we have seen, either directly or through the medium of Norman-French.

Teutonic v. Romance. These two elements have blended together to form our modern language. But we must never forget that the basis, or framework, is Teutonic or Anglo-Saxon. It is true that there are more than twice as many classical or Romance words in our language as Anglo-Saxon, the numbers given by some authorities being respectively 29,000 and 13,000. Yet the majority of those used belong to Anglo-Saxon, and when we want to express our finest feelings, or to interpret the deepest things of life, we naturally resort to that language. It is at once the simplest and the most dignified. A wise writer, of course, will avail himself of both elements; in fact, he cannot help himself. But he will see to it that while the superstructure may be Romance, the basis of his language will be Anglo-Saxon. He will never choose a classical word when a Teutonic one will do equally well. As a rule, the Teutonic words are the shorter. Most words of three or more syllables, and many of those of two, are classical; while in most words of one syllable, and very many of two, the Teutonic element prevails.

Teutonic Elements in English. The following are the chief Teutonic elements in our language: Pronouns, numerals, prepositions, conjunctions, adjectives of irregular comparison, auxiliary verbs, all verbs of strong conjugation, and some of weak; also most words relating to house, farm, family, parts of the body, common natural objects, common actions and things, trades, etc. On the other hand, words relating to law, religion, government, war, science, art, philosophy, are mostly classical.

One great advantage given to the English language by this blending of two distinct elements is that it is particularly rich in words of similar though not identical significance. It can, therefore, express delicate shades of meaning that are impossible to other languages. Notice, for example, the following list of pairs, one word being Teutonic, the other classical:

Teutonic.	*Classical.*	*Teutonic.*	*Classical.*
cold	frigid	breadth	extent
hard	difficult	wedlock	matrimony
bitterness	acerbity	feeling	sentiment
God	deity	life	existence
work	labour	love	passion

Teutonic.	*Classical.*	*Teutonic.*	*Classical.*
maw	stomach	world	universe
bloom	flower	worship	adoration
hearers	audience	fire	conflagration

This list might be extended almost to any length. It will be noticed that, on the whole, the Teutonic words are more "nervous" and expressive than the classical. As a rule, they come first to one's mind, the others being employed subsequently to avoid repetition, or to amplify the meaning. Naturally, our finest poetry is largely composed of the Teutonic element. Shakespeare is well worth studying from this point of view alone. The Authorised Version of the Bible, Bunyan and Defoe contain whole paragraphs composed almost entirely of Saxon words. For simplicity and pathos there is nothing to beat Anglo-Saxon. What is the charm of such a piece as, say, Tennyson's "Crossing the Bar"? Surely it is the fact that it contains hardly any but Saxon words:

> Sunset and evening star,
>   And one clear call for me,
> And may there be no moaning of the bar
>   When I put out to sea.
>
> But such a tide as moving seems asleep,
>   Too full for sound and foam:
> When that which drew from out the boundless deep
>   Turns again home.
>
> Twilight and evening bell,
>   And after that the dark:
> And may there be no sadness of farewell
>   When I embark.
>
> For tho' from out our bourne of time and place
>   The flood may bear me far,
> I hope to see my Pilot face to face
>   When I have crossed the bar.

How many words of classical origin can you count there?

Perhaps the best modern example of the classical style is to be found in the works of the late Frederick William Farrar. If we open them at any page, we find majestic, sonorous sentences, almost every other word of which is of classical origin. For example:

"Christ willed that they should be husbands, and fathers, and citizens, not eremites or monks. He would show that He approved the brightness of pure society, and the mirth of innocent gatherings, no less than the ecstasies of the ascetic in the wilderness or the visions of the mystic in his lonely cell. . . . Christ came not to revolutionise, but to ennoble and sanctify. . . . He came to teach that the service which God loved was not ritual and sacrifice, not pompous scrupulosity and censorious orthodoxy, but mercy and justice, humility and love. He came, not to hush the natural music of men's lives, nor to fill it with storm and agitation, but to re-tune every silver chord in that 'harp of a thousand strings' and to make it echo with the harmonies of heaven."

Relation of English to Other Languages. The languages of the world are arranged in families, according to resemblance in grammar and vocabulary. One of these families is known as the *Indo-European*, or *Aryan* family. It includes:

1. *Sanscrit*, which is the classic language of India, and exhibits the Aryan grammar in its most perfect form.
2. *Persian*, the earliest literary form of which is called Zend.
3. *Slavonic*, including Russian, Polish, Lithuanian, Lettish, etc.
4. *Græco-Latin*, including Greek and Latin, together with the "Romance" languages derived from Latin, such as French, Italian, Spanish, and Portuguese.
5. *Keltic*, comprising Gaelic (*i.e.*, Irish or Erse, Manx, and Scottish Gaelic), and Cymric (*i.e.*, Welsh and the Armorican of Brittany).
6. *Teutonic*. This group is divided into two main sections, Scandinavian and German. Scandinavian includes Icelandic, Swedish, Norwegian, and Danish. German comprises High German (the languages spoken in South Germany) and Low German (the languages spoken in the northern lowlands of Germany). To this latter section (Low German) English belongs, and has, for its nearest neighbours, Frisian, Dutch, Flemish, and Platt-Deutsch.

Not all the European languages are of Indo-European stock. Turkish, Finnish, and Hungarian (*i.e.*, Magyar), for example, are of a different stock. They have been introduced from Central Asia in comparatively modern times.

Grimm's Law. In addition to words that have been imported into English, there are many English words, or roots of words, that are common to most of the Aryan languages. These have not been borrowed by one from another, but all the different languages have received them from some earlier source. It has been noticed that in each set of these words common to several Aryan languages there is a certain relation existing between the consonants. The expression of this relation is known as "Grimm's Law," because it was stated by Jacob Grimm (1785–1863). It is given by Mason as follows: "If the same roots or the same words exist (1) in Sanscrit, Greek, Latin, etc.; (2) in Gothic or the Low German dialects; and (3) in Old High German, then

1. When the first class have an aspirate, the second have the corresponding soft check (*i.e.*, flat mute), the third the corresponding hard check (*i.e.*, sharp mute).
2. When the first class have a soft check (flat mute), we find the corresponding hard check (sharp mute) in the second class, and the corresponding aspirate in the third.
3. When the first class have a hard consonant (sharp mute), the second class have the aspirate, and the third the soft check (flat mute). In this third section of the rule, however, the law holds good for Old High German only as regards the *dental* series of mutes, the flat guttural being generally replaced by *h*, and the flat labial by *f*.

Examples :

Greek	Latin	Sanscrit	English	Gothic	Old High German
1.					
chēn	(h)anser	hansa	goose	gans	kans
thēr	fera	—	deer	dius	tior
phero	fero	bhri	bear	baira	piru
2.					
gnomi	gnosco	jnâ	know	kan	chan
deka	decem	dasan	ten	taihun	zehan
kannabis	—	—	hemp	—	hanaf
3					
kardia	cordis	hridaya	heart	hairto	(herza)
treis	tres	trayas	three	threis	dri
huper	super	upari	over	ufar	ubar

The student will find it interesting to take other words, such as *garden, daughter, door, dare, middle, brother, beech, be, kin, knee, foot, two, tooth, help, thou, other, father, full, fish*, etc., and trace their relationship with kindred words of other Aryan languages along the lines of this general law. English thus ceases to be an independent language, arbitrarily invented for our exclusive use. We see it to be a gradual growth, a single member of a large family of tongues, with brothers and sisters, nephews and cousins, closely related to it on all sides. It thus falls into its place in the general scheme of evolution.

Concluded

FRENCH

Continued from page 1621

By Louis A. Barbé, B.A.

NUMERALS—Continued

IV.—Collective and Approximative Numerals

By the addition of *aine* to certain cardinal numbers, numerals are formed that sometimes indicate a collection, sometimes an approximation.

1. *Huit, huitaine. Huitaine* is chiefly used as "a week," in expressions of "time how long," as : *J'ai passé une huitaine de jours à Paris,* I spent a week (or, about a week) in Paris ; *remettre à huitaine,* to postpone for a week. As a measure of time, "a week" is *une semaine* : The year has 52 weeks, *l'année a cinquante-deux semaines.*

2. *Neuf, neuvaine. Neuvaine* is used only in an ecclesiastical sense in the Catholic Church, and means a novena—*i.e.*, nine days' devotions.

3. *Dix, dizaine* (*x* changed into *z*). *Dizaine* is used approximately, "about ten," except in numeration : *les unités et les dizaines,* units and tens ; *une dizaine de francs,* about 10 francs.

4. *Douze, douzaine* (e omitted). *Douzaine* is used both collectively and approximatively : *Trois douzaines d'œufs,* three dozen eggs ; *il n'y a guère qu'une douzaine de personnes,* there are hardly more than a dozen people.

5. *Quinze, quinzaine. Quinzaine* is used for a "fortnight" in the same way as *huitaine* for a "week." It is also approximative : *Une quinzaine de francs,* about 15 francs.

6. *Vingtaine* (20), *trentaine* (30), *quarantaine* (40), *cinquantaine* (50), *soixantaine* (60), *centaine* (100), are used approximatively : *Une vingtaine de lignes,* about 20 lines ; *une centaine de pages,* about 100 pages.

7. *Mille* has the collective and approximative form *millier* : *Des milliers de francs,* thousands of francs.

8. Multiplicative numerals are : *une fois, deux fois, trois fois,* etc., once, twice, three times, etc.

V.—Time

The hour of the day is expressed as follows :

Une heure, one o'clock.

Une heure cinq, five minutes past one.

Une heure et quart
Une heure un quart
Une heure et un quart } a quarter past one.

Une heure et demie, half past one.

Deux heures moins vingt-cinq, 25 minutes to two.

Une heure trois quarts
Deux heures moins un quart
Deux heures moins le quart } a quarter to two.

Midi et demi, half past twelve (noon).

Minuit et demi, half past twelve (night).

The expressions "a.m." and "p.m." are rendered by *du matin, du soir* : *de dix heures du matin à dix heures du soir,* from 10 a.m. to 10 p.m.

VI.—Dimension

Dimension may be expressed either attributively (without a verb) or predicatively (with a verb).

To express dimension attributively there are three constructions :

1. In the first the noun is followed by an adjective of dimension agreeing with it in gender and number, then by *de,* and lastly by the numeral and noun of measure : *Un mur haut de trois mètres,* a wall three metres high. The other adjectives used in this way are : *long,* long ; *large,* broad ; *profond,* deep ; *épais,* thick.

2. In the second the noun is followed by *de,* with the numeral and noun of measure, and then by another *de* with an invariable adjective of dimension : *Une table de deux mètres de long,* a table two metres long.

This construction is not used with *profond* or *épais.*

3. In the third the last word, instead of being an invariable adjective, is a noun of dimension : *longueur, largeur, hauteur, profondeur, épaisseur, diamètre, circonférence* : *Un fossé de deux mètres de profondeur,* a ditch two metres deep.

To express dimension predicatively either *être* or *avoir* may be used.

1. With *être* the verb is followed by an adjective agreeing in gender and number with the subject of the verb, and then by *de* with the numeral and noun of measure : *Cette salle est longue de cinq mètres,* this room is five metres long.

2. With *avoir* there are two constructions. In the first the verb is followed by the numeral

and noun of measure, and then by *de* with a noun of dimension: *Ce mur a dix mètres de longueur*, this wall is ten metres long.

In the second the last word is an invariable adjective of dimension: *Cette maison a quinze mètres de haut*, this house is 15 metres high.

3. Another construction may also be used, corresponding to the English, as: A height of ten feet, *une hauteur de dix pieds ;* this wall has a thickness of six inches, *ce mur a une épaisseur de six pouces*.

De is used in French, though not in English, after the verb "to be" in the measurement of any number or quantity: The population is 7500, *la population est de sept mille cinq cents ;* the distance is ten miles, *la distance est de dix milles*.

4. Square measure is expressed by means of the preposition *sur :* *Une plaine de six milles de long sur six de large*, a plain six miles long by six broad.

Sur is also used with numbers, in the sense of "out of": *Nous avons eu deux beaux jours sur dix*, we have had two fine days out of ten.

VII.—Numerals with "En"

When in a sentence a numeral is used without the noun to which it refers, that noun being understood, the pronoun *en* must be used. Its place is immediately before the verb: You have fifteen francs, I have only ten, *Vous avez quinze francs, je n'en ai que dix.*

VIII.—Numerals with "À"

1. In English, when "place where" is indicated in terms of distance, the preposition "at" is omitted. In French the preposition *à* must be used:

Versailles est à vingt-trois kilomètres de Paris, Versailles is twenty-three kilometres from Paris ; *Il demeure à dix milles de Londres*, he lives ten miles from London.

2. Between the same numeral repeated, *à* is used to express combination, or union:

Ils marchent deux à deux, they walk two by two.

3. In scoring, at certain games, *à* is used after a numeral to express equality:

Quinze à, Fifteen all !

IX.—Numerals with "De"

1. *De* is used instead of *que*, for "than" before numerals, when no real comparison is expressed:

Vous avez plus de dix fautes, You have more than 10 mistakes.

2. After a numeral (with a noun expressed or understood), "more than," "less than," are rendered by *de plus, de moins :*

J'ai deux fautes de moins que vous, I have two mistakes less than you ; *Vous avez cinq francs de plus que nous*, you have five francs more than we.

3. These two uses of *de* may be combined:

Il a plus de cinq cents volumes de plus que vous, he has more than 500 volumes more than you.

4. In comparison *de* indicates the measure of excess or of inferiority:

Plus âgé de dix ans, older by ten years.

5. When the substantive to which a numeral refers is represented by the pronoun *en*, placed before the verb, the adjective that follows the numeral must have *de* before it:

Sur mille habitants, il n'y en a pas dix de riches, out of a thousand inhabitants, there are not 10 rich.

Exercise XIII.

1. We have spent about a fortnight in London.

2. I have bought (*acheté*), half a pound of butter and half a dozen eggs.

3. In ninety-seven there are nine tens and seven units.

4. There are about a hundred pages in the copy-book (*cahier*).

5. What time is it ? It is ten minutes past four ; in five minutes it will be (*sera*), a quarter past four, and in twenty minutes it will be half-past four.

6. This street is half a mile long and fifty feet broad.

7. Our house is more than forty feet high.

8. This table is two metres long by one metre seventy-five centimetres broad.

9. You have three mistakes (*fautes, f.*) ; I have only one.

10. Dover (*Douvres*), is about (*environ*) twenty-one miles from Calais.

11. The Straits of Dover (*le Pas de Calais*), are more than twenty miles broad.

12. You have earned (*gagné*), more than fifty francs more than we.

Key to Exercise XII.

1. Trois, cinq, sept, onze, douze, quinze, dix-neuf, vingt et un, vingt-deux, trente, trente et un, quarante-quatre, cinquante-cinq, cinquante-huit, soixante, soixante-neuf, soixante-dix, soixante et onze, quatre-vingts, quatre-vingt-neuf, quatre-vingt-onze, quatre-vingt-dix-neuf, cent, deux cent dix, trois cent cinquante, sept cent quatre-vingt-neuf, neuf cent onze, neuf cent quatre-vingt-dix-neuf, mil deux cent trente-quatre.

2. Premier, deuxième, second, quatrième, cinquième, neuvième, vingtième, vingt et unième, trente-deuxième, quarante-cinquième, cinquante et unième, soixante-sixième, soixante-dixième, soixante et onzième, quatre-vingtième, quatre-vingt-unième, quatre-vingt-neuvième, quatre-vingt-dixième, quatre-vingt-onzième, quatre-vingt-dix-neuvième, centième.

3. Un et un font deux, et deux font quatre, et quatre font huit, et huit font seize, et seize font trente-deux, et trente-deux font soixante-quatre, et soixante-quatre font cent vingt-huit.

4. Deux fois un font deux ; trois fois deux font six ; quatre fois six font vingt-quatre ; cinq fois vingt-quatre font cent vingt.

5. La minute contient soixante secondes.

6. La seconde est la soixantième partie d'une minute.

7. La lumière emploie huit minutes treize secondes à venir du soleil.

8. Dans une heure il y a soixante minutes.

9. Le jour est un espace de vingt-quatre heures.

10. De minuit à midi il y a douze heures.

11. L'année est composée de trois cent soixante-cinq jours et un quart.

12. La semaine a sept jours; le mois a quelquefois trente et un jours, quelquefois trente jours et quelquefois vingt-huit seulement.

13. Le mois de février, le deuxième mois de l'année, a vingt-huit jours.

14. L'année commence le premier janvier; elle finit le trente et un décembre.

15. Le mois de décembre est le dernier mois de l'année.

16. La fête de Noël tombe toujours le vingt-cinq décembre.

17. Le vingtième siècle a commencé le premier janvier mil neuf cent un.

18. Quel est le quantième? C'est le premier décembre.

Continued

GERMAN

Continued from page 1653

By P. G. Konody and Dr. Osten

XXV. The PREPOSITIONS [see XV.] which govern alternately the *dative* and the *accusative*, are: an (at, on, upon, by, near); auf (on, upon, in, at, up); hinter (behind, after); in (in, into, at); neben (by, near, by the side of, beside); über (over, above, on, upon, at, about); unter (under, below, among, between); vor (before, ago, since); zwiſchen (between, betwixt, among).

1. The preposition governs the dative if the sentence answers the question wo? (where?); whilst wohin? (whither, where to?) is answered by the accusative: thus the dative implies a state of rest, the accusative of motion.

EXAMPLES: Das Buch liegt auf (3) dem Tiſche, the book lies on the table [where? Dative: on the table]. Ich lege das Buch auf (4) den Tiſch, I put the book on the table [whither? Accusative: on the table]. Der Käfer kriecht auf (3) dem Tiſche, the beetle crawls on the table (implying that the beetle is crawling about on the table). Der Käfer kriecht auf (4) den Tiſch (implying the act of crawling on to the table).

2. The *dative* and *accusative* of the definite article of the dependent noun is often contracted with the governing preposition. The dative singular, masculine and neuter dem may be contracted with the prepositions bei (3), near, about, with, at; von (3), from, of; zu, to, at, by: bei dem, von dem, zu dem, are contracted into beim, vom, zum.

Zu is also contracted with the dative of the feminine definite article der: zu der = zur.

The prepositions durch (4), through, by; um (4), around, about, for; and für (4), for are contracted with the accusative of the neuter definite article das: durch das, um das, für das, into durchs, ums, fürs.

The prepositions an and in are contracted with the *dative* singular, masculine, and neuter dem: an dem = am, in dem = im.

The prepositions an, auf, hinter, in, über, unter, vor, are contracted with the *accusative* singular neuter das into: ans, aufs, hinters, ins, übers, unters, vors: and hinter, über, unter, vor, with the *dative* and *accusative* masculine dem and den into: hinterm (3), hintern (4); überm (3), übern (4); unterm (3), untern (4); vorm (3), vorn (4).

EXAMPLES: Er war im [in (3) dem] Zimmer, he was in the room [where? *dat.*]. Er ging ins [in (4) das] Zimmer, he went into the room [whither? *accus.*]. Ich ging zum [zu (3) dem] Arzte, I went to the doctor. Ich war beim [bei (3) dem] Arzte, I was at the doctor's. Er lief durchs [durch (4) das] Thor und ums [um (4) das] Dorf, he ran through the gate and around the village. Das Bild hängt unterm [unter (3) dem], überm [über (3) dem] Spiegel, the picture hangs underneath, above, the mirror. Er legte ſich aufs [auf (4) das], ins [in (4) das] Gras, he laid [himself] down on (*or*, in) the grass [on what? *accus*]. Er legte ſich im [in (3) dem] Graſe nieder, he lay down on the grass [where? *dat.*].

XXVI. The ATTRIBUTIVE ADJECTIVE [see VIII., *a*] agrees in gender, number, and case with the substantive which it qualifies, and may therefore take the weak, the strong, or the mixed declension.

1. When preceded by the definite article [I., p. 745] or by a determining noun of corresponding flective termination, pronoun, etc., the adjective takes the weak declension.

EXAMPLE: gut, good, declined as attributive adjective in:

		der gut-e Vater (*m.*)	die gut-e Mutter (*f.*)	das gut-e Kind (*n.*)
Sing.	1.	der gut-e Vater	die gut-e Mutter	das gut-e Kind
,,	2.	des gut-en Vaters	der gut-en Mutter	des gut-en Kindes
,,	3.	dem gut-en Vater	der gut-en Mutter	dem gut-en Kinde
,,	4.	den gut-en Vater	die gut-e Mutter	das gut-e Kind
Pl.	1.	die gut-en Väter	die gut-en Mütter	die gut-en Kinder
,,	2.	der gut-en Väter	der gut-en Mütter	der gut-en Kinder
,,	3.	den gut-en Vätern	den gut-en Müttern	den gut-en Kindern
,,	4.	die gut-en Väter	die gut-en Mütter	die gut-en Kinder

(*a*) In this declension the adjectives take the inflection -e in the nominative singular of all genders, and in the accusative singular of the feminine and neuter genders.

(*b*) All other cases take the inflection -en.

2. The adjective takes the inflections of the *strong* declension, when it is not preceded by the article or by a determining noun with the inflections of the definite article [see V., 3].

Sing.	1.	gut-er Vater (*m.*)	gut-e Mutter (*f.*)	gut-es Kind (*n.*)	*Pl.* 1.	gut-e Väter, Mütter, Kinder
”	2.	gut-en* Vaters	gut-er Mutter	gut-en* Kindes	” 2.	gut-er Väter, Mütter, Kinder
”	3.	gut-em Vater	gut-er Mutter	gut-em Kinde	” 3.	gut-en Vätern, Müttern, Kindern
”	4.	gut-en Vater	gut-e Mutter	gut-es Kind	” 4.	gut-e Väter, Mütter, Kinder

3. The adjective takes the *mixed* declension when preceded by the indefinite article [See V., 4] or by a determining noun with corresponding declensive terminations.

Sing.	1.	ein gut-er Vater (*m.*)	eine gut-e Mutter (*f.*)	ein gut-es Kind (*n.*)
”	2.	eines gut-en Vaters	einer gut-en Mutter	eines gut-en Kindes
”	3.	einem gut-en Vater	einer gut-en Mutter	einem gut-en Kinde
”	4.	einen gut-en Vater	eine gut-e Mutter	ein gut-es Kind

In the plural the adjectives take the inflections of the *strong* declension, if unattended [see XXVI., 2], or of the weak declension, if attended by the definite article or equivalent nouns.

4. The inflections in the declension of the attributive adjective with the definite, with the indefinite, and without article or corresponding noun [see 1, 2, 3], are summarised in the following table.

	Singular			Plural		
	Masculine	*Feminine*	*Neuter*	*Masculine*	*Feminine*	*Neuter*
1. *nominative*	der ..-e ein ..-er ..-er	die ..-e eine ..-e ..-e	das ..-e ein ..-es ..-es	die ..-en — ..-e	die ..-en — ..-e	die ..-en — ..-e
2. *genitive*	des ..-en eines ..-en ..-en	der ..-en einer ..-en ..-er	des ..-en eines ..-en ..-en	der ..-en — ..-er	der ..-en — ..-er	der ..-en — ..-er
3. *dative*	dem ..-en einem ..-en ..-em	der ..-en einer ..-en ..-er	dem ..-en einem ..-en ..-em	den ..-en — ..-en	den ..-en — ..-en	den ..-en — ..-en
4. *accusative*	den ..-en einen ..-en ..-en	die ..-e eine ..-e ..-e	das ..-e ein ..-es ..-es	die ..-en — ..-e	die ..-en — ..-e	die ..-en — ..-e

5. (*a*) The e of the inflections -e, -em, -en, -er, and -es is dropped in adjectives ending in an unstressed -e, like böſe, bad; blöde, shy, timid; müde, tired weary; träge, lazy · weiſe, wise. These add only -m, -n, -r, and -s—*e. g.*: *s.* 1. der weiſe Vater, *s.* 2. des weiſe-n Vaters, *s.* 3 weiſe-m Vater, *s.* 3. weiſe-r Mutter, *s.* 1. weiſe-s Kind, etc.

(*b*) Adjectives ending in -el and -er (edel, noble; heiter, merry) cast off the e of this termination, for reasons of euphony, when they take the flective -e, -er, or -es (der ed[ ]l-e Vater, ed[e]l-es Kind, ed[e]l-er Vater, die heit[e]r-e Mutter, heit[e]r-es Kind).

(*c*) When inflected with -em or -en either both e's are retained (heiter-em, heiter-en, edel-em, edel-en), or *one of them* is dropped (ed[e]l-em and edel-[e]m, ed[e]l-en and edel-[ ]n, heit[e]r-em and heiter-[ ]m, heit[e]r-en and heiter-[e]n, etc.).

(*d*) Adjectives ending in -en (golden, golden), drop the e of this termination when the inflections mentioned in (*a*) are added (der gold[ ]n-e, gold[e]n-em, gold[e]n-en, gold[e]n-er, and gold[e]n-es).

(*e*) Adjectives ending in -nen retain the e in this termination when inflections are added (beſon'nen, considerate; der beſonnen-e, beſonnen-em, etc.).

(*f*) The adjective hoch, high, casts off in its declension the c of the guttural terminatiom -ch: der hoh-e, hoh-em, hoh-en, hoh-er, hoh-es.

EXAMINATION PAPER VIII.

1. By which questions is it possible to determine the declensive case a noun must follow, if it depends on a preposition governing the dative and accusative alternately?
2. With which articles can certain prepositions be connected and in which declensive cases? Which component remains unaltered, which part of the other is dropped, and which retained for the new compound?
3. How many forms of declension are possible with the attributive adjective, and which of them is used if the adjective is preceded by the definite, by the indefinite, or by no article at all?
4. What terminations are characteristic of the weak declension of attributive adjectives, and in which cases are these terminations used?
5. Is the attributive adjective unalterably bound to one system of declension, like the substantive, or can it undergo all declensions alternately? On what circumstances does the employment of one or the other system depend?

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* An alternative *strong* masculine and neuter genitive -es: gut-es $\left\{\begin{array}{c}\text{Vaters}\\ \text{Kindes}\end{array}\right\}$ is obsolete and only retained in several idiomatic expressions, like keinesfalls [kein-es Falles], in no case; jedesfalls [jed-es Falles], at all events, etc.; and even these words are also used with the genitive -en: keinenfalls, jedenfalls, etc. The modern form is preferable.

6. **How are the declensive inflections added to adjectives ending in an unstressed -e, -el, -er, -en, and -nen?**
7. **What irregularity is to be noted in the declension of the attributive adjective hoch (high)?**

Exercise 1. (*a*) Insert the missing words and declensive inflections as governed by the prepositions:

Eine Marke war auf .... Brief.. (*m*) Stecke den
A stamp was on the letter. Put the
Brief in .... Taſche (*f.*)! Iſt der Brief in ....
letter in the pocket! Is the letter in the
Taſche? Das Haus ſteht hinter .... Kirche (*f.*).
pocket? The house stands behind the church.
Wir waren ge'ſtern in ... Kirche (*f.*); wir gingen
We were yesterday in [the] church; we went
ge'ſtern in .... Kirche. Sie waren hinter ....
yesterday to [the] church You were behind me
und er eilte hinter ....; wir ruhten unter
and he hastened behind me: we rested under
.... Baum ... (*m.*). Gehen Sie unter .... Baum!
the tree. Go [you] under the tree!
Das Haus liegt zwiſchen .... Fluß ... (*m*) und
The house [lies] is situated between the river and
.... Wieſe (*f.*). Er ſteht vor .....; ſie ſtellt
the meadow. He stands before you; she puts
den Tiſch vor .... Bett (*n.*); er ſaß neben .... auf
the table before the bed; he sat beside me on
.... Bank (*f.*). Die Uhr hängt über .... Bild .. (*n.*)
the bench. The clock hangs above the picture
an .... Wand (*f.*). Er lief über .... Brücke (*f.*).
on the wall. He ran over the bridge.

(*b*) Insert the missing definite articles and form the corresponding contractions of these articles and the prepositions.

Ich war bei......... Arzte (*m.*) und blieb dann bei
I was at the physician's and stayed then with
.... Mutter. Es geſchah bei .... Brücke (*f.*) nahe
the mother. It happened at the bridge close
bei......... Wäldchen (*n*); er ging zu.........
to the (*dimin.*) wood; he went to the
Arzte und dann zu......... Mutter. Hier ſind Briefe
doctor and then to the mother. Here are letters
vo......... Arzte, von .... Mutter, und vo.........
from the doctor, from the mother, and from the
Kinde; ich kam von .... Tante und ging dann
child! I came from the aunt and went then
zu......... Mutter; er kam aus .... Hauſe (*n.*);
to the mother; he came out of the house;
ich ging in......... Haus. Er wanderte... ....
I went into the house. He walked through the
Thor (*n.*),... .... Mühle (*f.*), durch .... Garten (*m.*),
gate, through the mill, through the garden.
... . Dorf (*n.*)... .... Feld (*n.*) und
round the village into the field and
dann ... . Schloß (*n.*). Er hatte die Feder
then up to the castle. He had the pen
... . Ohre (*n.*). Der Hund liegt ... .
behind the ear. The dog lies under the
Tiſche (*m.*); wir ſaßen... .... Kamin' (*m.*); er
table; we sat by the fireside; he
hatte eine Cigarre... .... Munde (*m.*); wir gingen
had a cigar in the [his] mouth; we went
in .... Schule (*f.*), in .... Park (*m.*),... ....
to [the] school, into the park, to the
Thea'ter (*n.*). Er kämpfte ... . Vaterland (*n.*).
theatre. He fought for the fatherland.

Er ſprang ... . Pferd (*n.*) und galloppier'te
He jumped on the horse, and galloped
... . Feld (*n.*),... .... Gras (*n.*),
across the field, through the grass,
durch .... Wald (*m.*), ... Wieſe (*f.*).
through the wood, over the meadow.
Ich ſtellte mich ... . Thor (*n.*)
I posted myself before the gate.

Exercise 2. Add the missing declensive inflections to the attributive adjectives:

Ein gut... Lehrer (*m.*) lobt nicht einen faul...
A good teacher praises not [does not praise] a lazy
Schüler (*m.*); der gut... Lehrer lobt den fleißig..
scholar: the good teacher praises the diligent
Schüler. Gut.. Lehrer loben die gut... Schüler.
pupil. Good teachers praise the good pupils.
Er war der glücklich.. Vater einer ſchön... Tochter
He was the happy father of a beautiful daughter
und eines begabt... Sohnes; ſie war die liebevoll..
and of a gifted son; she was the loving
Tochter ein... ehrſam... Schulmeiſters und
daughter of a respectable schoolmaster and
hei'ratete einen gut... Freund des geliebt... Vaters.
married a good friend of the [her] beloved father.
Die Söhne bedeutend... Väter ſind nicht
The sons of important [great] fathers are not
immer bedeutend.. Männer. Gut.. Mütter ſind ein
always important men. Good mothers are a
Segen; die gut... Mütter ſind die verläß'lich...
blessing; [the] good mothers are the reliable
Grundlagen der menſchlich... Geſell'ſchaft. Wir
foundations of [the] human society. We
ſuchten nach (3) weiß... Brot (*n.*) und nach (3) friſch...
searched for white bread and for fresh
Milch (*f.*). Das zart.. Fleiſch (*n.*) ſtand auf (3) dem
milk. The tender meat stood [was] on the
Tiſche; ich liebe reif.. Äpfel (*m.*); die reif... Äpfel
table; I love ripe apples; [the] ripe apples
ſind ſüß; die Süße reif... Pfir'ſiche iſt
are sweet; the sweetness of ripe peaches is
köſtlich. Das Mädchen trug eine golden.. (or gold...)
delicious. The girl carried a golden
Kanne (*f.*) gefüllt mit edel... (or ed...) Weine (*m.*),
can filled with precious wine.
Xantippe war die böſe Gattin eines weiſ... Mannes.
Xantippe was the malicious wife of a wise man.
Wir ſaßen in dem dunkel... (or dunk...) Zimmer (*n.*);
We sat in the dark room;
wir ſaßen in einem dunkel... (or dunk...) Zimmer;
we sat in a dark room;
er benützte den eben.. (or eb...) Weg (*m.*); wir wanderten
he used the level way [path]; we walked
auf dem eben... (or eb...) Wege; der eben.. (or eb...)
on the level path; the level
[ein eben... (or eb...)] Weg iſt gut. Wir tranken den
(a level) path is good. We drank the
bitter.. (or bitter...) Wein (*m.*); bitter... (or bitt...) Wein
bitter wine; bitter wine
hat einen ſchlecht... Geſchmack, (*m.*); der bitter... (or bitt...)
has a bad taste; the bitter
Wein war teuer; ich liebe ſauer.. (or ſau..) Milch (*f.*);
wine was dear; I like sour milk;
ſauer... (or ſau...) Obſt (*n.*) und das ſauer.. (or ſau...)
sour fruit and the sour
Getränk (*n.*) ſind ungeſund
beverage are unwholesome.

Continued

End of Second Volume.